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Royal Australian Navy Aerospace Capability 2020-2030

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About the Author

Lieutenant Daniel Hosick joined the RAN in January 1994 as a Seaman Officer. He graduated from the Australian Defence Force Academy in 1996. In 1997 he commenced his SEAAC training at HMAS WATSON prior to posting to HMAS PERTH as a Junior Officer Under Training. He served aboard PERTH from late 1997 to late 1999 in which time he was awarded his Bridge Watchkeeping Certificate and consolidated as an Officer of the Watch. He joined HMAS WARRNAMBOOL as the Navigating Officer in late 1999. In early 2002 he joined the Bridge Simulator at HMAS WATSON as an Instructor. In January of 2003 he joined Navy Headquarters as the Staff Officer to the Director-General Navy Capability Performance and Plans.

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Abstract

This paper discusses the future of Royal Australian Navy (RAN) aerospace capabilities over the period 2020-2030, examining developing technologies, their potential utilisation, and how the RAN can build a robust aerospace capability to ‘fight and win at sea’. The future ability of the ADF to provide flexible capability options to government to protect national interests against a myriad of foreseeable and unknown security challenges will be limited, especially for the RAN as a medium power navy. The RAN will need to provide a wide range of solutions through a balanced mix of sea and aerospace platforms. The creation of such capabilities will be a difficult task, and one that needs careful preparation, sound development and solid doctrinal support. Aerospace power is a key element of capability that the RAN must not neglect, and one where it can derive immense military advantage if carefully fostered.

ACRONYMS

ABL	Airborne Laser
ADF	Australian Defence Force
AEW&C	Airborne Early Warning and Control
AMSTE	Affordable Moving Surface Target Engagement
ARA	Australian Regular Army
ASR	Annual Strategic Review
ASuW	Anti-Surface Warfare
ASW	Anti-Submarine Warfare
AWACS	Airborne Warning and Control System
BMC4I	Battlespace Management Command, Control, Communication, Computers and Intelligence
C2	Command and Control
CBRN	Chemical, Biological, Radiological, Nuclear
CEC	Cooperative Engagement Capability
CG(X)	Future USN Cruiser
CPB	Charged Particle Beam
CV	Aircraft carrier
CVN	Aircraft carrier, nuclear-powered
DD(X)	Future USN Destroyer
EBO	Effects Based Operations
ELINT	Electronic Intelligence
FWC	Future Warfighting Concept
GPS	Global Positioning System
GSTF	Global Strike Task Force
HPM	High Power Microwave
IADS	Integrated Air Defence System
INS	Inertial Navigation System
ISR	Intelligence, Surveillance and Reconnaissance
JSTARS	Joint Surveillance Target Attack Radar System
JSF	Joint Strike Fighter
LCS	Littoral Combat Ship
LOCAAS	Low Cost Autonomous Attack System
MC2A	Multi-sensor Command and Control Aircraft
MPA	Maritime Patrol Aircraft
NCW	Network-Centric Warfare
nm	Nautical Miles
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy

RF	Radio Frequency
RMA	Revolution in Military Affairs
RN	Royal Navy
SEAD	Suppression of Enemy Air Defences
STOVL	Short Take-Off/ Vertical Landing
TCA	Transformational Communication Architecture
TSV	Theatre Support Vessel
UAV	Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
UN	United Nations
USMC	United States Marine Corps
USN	United States Navy
UUV	Unmanned Underwater Vehicle
VLS	Vertical Launch System
WMD	Weapons of Mass Destruction

Introduction

The aim of this paper is to discuss the future of Royal Australian Navy (RAN) aerospace capabilities over the period 2020-2030. To do this three primary questions have been used to guide this discussion. Firstly, how may the Royal Australian Navy as a maritime force maximise its capability through the exploitation of aerospace power through the period 2020-2030? Secondly, what capabilities may the RAN acquire given present technologies that are reasonable for a medium power to operate and sustain in support of the Governments national security priorities? Thirdly, what will the impact of these capabilities be on the ability of the RAN to satisfy its primary sea control mission? This paper aims to outline what technologies may be available, how they may be utilised as present and future force elements within the fleet and what the RAN can try to do in order to build a robust aerospace capability to 'fight and win at sea'. It does not presume to dictate a specific force structure for the RAN Fleet Air Arm. Capability acquisition is an important issue, especially for a Navy aiming to satisfy varied national objectives with a limited budget. Wide and varied threats to Australian security and national interests will emerge over the next two decades. Sea and aerospace power are both important features in ensuring Australia's security, and both are essential for a Navy that seeks to win in the maritime environment. The transition of individual elements of advanced aerospace technologies into viable and formidable capabilities can give the RAN a significant war fighting advantage essential to modern combat power. Robust capability in the RAN order of battle will provide a wide range of solutions to protect the national interest. The creation of such capabilities will be a difficult task, and one that needs careful preparation, sound development and solid doctrinal support.

The Australian Security Environment

The Australian Defence Force (ADF) has been provided with a number of significant national security challenges in the 2000 White Paper and the annual strategic review (ASR), *Australia's National Security: A Defence Update 2003*.[1] These documents show, respectively, a shift from the earlier 'fortress Australia' defence of the air-sea gap to a more expeditionary role in a maritime concept of operations; and the suppression of terrorism and the prevention of Weapons of Mass Destruction (WMD) proliferation that may affect

Australia. Chief of Navy, Vice Admiral Shackleton described the strategic shift of the 2000 White Paper as ‘a recognition that the best way to defend yourself is to do it somewhere else.’[2] The present operational tempo of the ADF and the RAN reflects these wide strategic commitments. From conventional war fighting operations in Iraq, through peace keeping in East Timor, to immigration enforcement in the northern approaches, such examples demonstrate the many national interests to which the ADF contributes. Each of these documents has presented the strategic framework under which defence must develop ‘capabilities for the Defence of Australia and its National Interests.’[3]

It must be noted how diverse are the strategic challenges the ADF is facing, a strategic outlook which has been shifted within a relatively short period. With the end of the Cold War the numerous international humanitarian crises of the 1990s brought a series of unique challenges for military forces to adequately respond. The 1991 Gulf War was perhaps the most ‘normal’ conflict a western military was designed to wage, but the military responses to the varied humanitarian interventions under the auspices of the UN, such as Cambodia, Somalia and in the Balkans, all used the capabilities present at the time. When Australia contributed to various contingencies it did so with the capabilities it had, albeit these were geared towards the defence of Australia. Since the 2000 White Paper, the attacks of September 11 and the subsequent War on Terror have clearly demonstrated a new threat to Western security that was not previously envisaged. Since then, elements of ADF capability have been augmented or expanded to face the threat, but not radically changed.

The White Paper and ASR have highlighted Australia’s likely security needs. The ADF will ‘raise, train and sustain’ its capability to match the strategic outlook predicted. As demonstrated by history, particularly since the end of the Cold War, armed forces are called upon to respond to contingencies that are highly varied and most importantly, not always planned for. Figure 1 highlights the spectrum of operations in which the ADF could potentially participate. Understandably, if capability is planned a decade before its introduction, this can have a massive impact upon what is acquired and how successfully it serves to satisfy altered national objectives by the time of operational deployment.

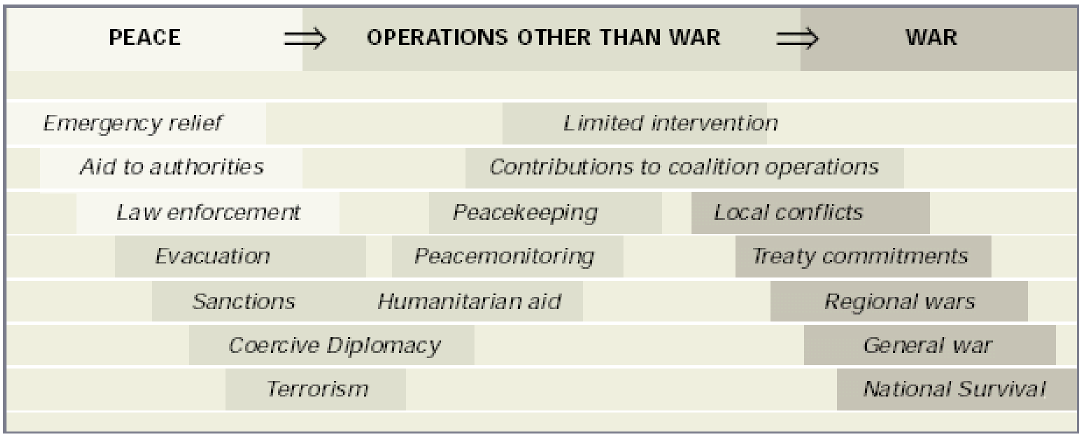

Figure 1: The Spectrum of Operations[4]

A national defence force must, therefore, possess capabilities that can meet the demands of government now, in the foreseeable future, and whatever may develop (this last factor of course cannot be anything more than speculative). These capabilities need to contribute to autonomous ADF operations or as part of a coalition force. Predictions of the future security environment see a variety of diverse contingencies. 'Traditional' issues such as sovereignty violations or protection of natural resources are still probable. Transnational threats include 'terrorism; illicit weapon and dual technology transfers[5], proliferation of chemical, biological, radiological, nuclear (CBRN) and missile technologies, unregulated migration, illicit drug production and trafficking, racketeering and money laundering, computer crime, infectious disease, environmental threats, and piracy and robbery at sea.'[6] The spread of fundamentalism, the depletion of natural resources and collapse of countries into 'failed states' are also threats to international security. The factors of where, when and to what extent any of these situations occur may be assessed, but not truly known unless they eventuate. Within the South East Asian region at present refugee migration, the illicit drug trade, HIV/AIDS infection rates, overfishing and water stress have all been identified by the Department of Foreign Affairs and Trade as contemporary 'transnational challenges' in our region.[7]

The changing nature of warfare will lead many nations to review their strategic outlook. Public and government concern for civilian casualties has led to the conduct of the recent war in Iraq, which has demonstrated the most precisely targeted military operation to date. Military technology is evolving so as to give added reach, timeliness, precision, and appropriate destructive power capabilities to armed forces. Such equipment is available at many different levels of the military scale. Each new technology available on the military market offers an enhancement of military capability, and equally so a threat that has to be countered. Likewise the highly speculative 'asymmetric' threats offered by proponents of 'Fourth Generation Warfare'[8] pose a difficult challenge to military planners, where conventional weapons and tactics are discarded by those who 'are not strong in technology,' but are able to derive a military or political advantage through 'ideas rather than technology.'[9] The success of such alternative operations demonstrated by the September 11 and USS *Cole* attacks shows both the potency and effect of asymmetric operations, where unconventional means caused immense destruction against the world's strongest conventional military power. Warfare will continue to change, and regardless of the advantage technology brings and the lessons that history may provide, the world's armed forces will still be

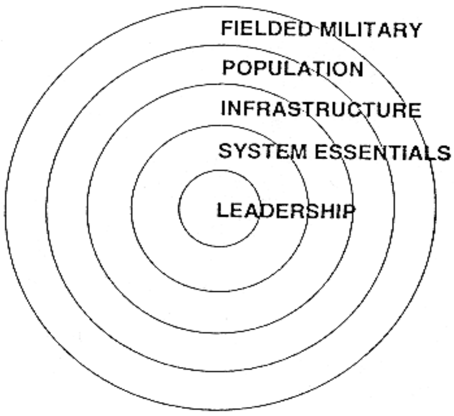

Figure 2: The System Model[1]

susceptible to conventional and unconventional operations, the fog of war and surprise. The emerging trends in warfare are reflected by the rapid change of those methods used to project military power articulated by doctrine. The doctrine of the ADF and the three services is constantly being revised and updated to remain flexible and responsive the needs of contemporary strategic thinkers who aim to address the changes in modern war fighting.[10]

Aerospace power facilitates a response to the needs of government to satisfy political objectives that cannot always be offered by land and sea power. The genesis of the successful 1991 Gulf War air campaign grew through a close examination of the strategic nature of the Iraqi regime, and the System Model diagram at Figure 2 was the simplified version of how to treat it. The air campaign focused on the strategic importance of elements of the Iraqi regime, and then developed a campaign that maximised the allied military advantages to strategically target Iraqi weaknesses and nodes of importance. Aerospace power demonstrated its ability to provide the military options that would most effectively serve to produce the strategic results. The importance and utility of air power in a variety of operations since the first Gulf War is readily apparent, with Kosovo and the 'shock and awe' campaign of the recent war in Iraq prominent examples. Air power in this respect can also deliver politically palatable options that ground or sea forces cannot always achieve. Aerospace power provides a government with strategic effects from precision air campaigns with the benefit of a minimal number of personnel exposed to danger, and avoiding the need for large sea and land forces to force a resolution. The war in Kososvo exemplified how air power could exert leverage to effect the desired political outcome without the need for ground troops to be involved in direct fighting and holding ground.

Though aerospace power may offer significant advantages to government in modern war, it may not always be possible or prudent to use. The RAN's contributions to recent operations amply demonstrate this. Maritime interception operations in the Persian Gulf during Operation Slipper in support of United Nations sanctions against Iraq needed naval surface ships to enforce the UN resolutions. This could not have been done by aerospace platforms. The East Timor intervention relied heavily on sealift provided by RAN and merchant marine assets, where strategic air lift could not meet every contingency, nor meet the volume of demand. These operations and those cited in the preceding paragraph are not intended to develop an 'us and them' attitude between sea and air power pundits. The point is that some operations will rely more heavily on one force than another, and that one type of power cannot be utilised to the exclusion of others if operations are to be executed efficiently. Without carriers in the Adriatic for the Kosovo example, air operations would not have been as responsive or comprehensive. Without land based maritime patrol and organic rotary wing picture compilation in the North Arabian Gulf, naval operations would not have been as efficient or effective in stopping the flow of illegal oil.

What then are the differences between aerospace power and sea power? The characteristics of aerospace power are numerous: concentration of force, concurrent operations, fragility, impermanence, operating bases, payload, penetration, battlespace perspective, precision, reach, responsiveness, speed, technology, tempo, and versatility.[11] These characteristics provide both advantages and disadvantages at the strategic, operational and tactical levels. Sea power also offers a series of capability characteristics: mobility in mass, readiness, access, flexibility, adaptability, reach, poise and persistence, and resilience.[12] The limitations of maritime power are transience, indirectness, and speed.[13] When all these characteristics are placed together, a capability mix can be determined that enables joint sea and aerospace power to prevail, maximising advantages and minimising the weaknesses.

The zenith of the aerospace/sea power force mix can perhaps be seen in the military dominance of the carrier battle group, whose naval mobility, mass, access and persistence complement the concurrent operations, penetration, precision, reach and speed capabilities of aerospace power. Aerospace or sea power may be suitable for employment exclusively, but it is through joint operations that success in the modern maritime environment can be achieved. These advantages, when combined within the maritime battlespace, provide the military option of power projection anywhere in the open ocean and littoral environments, far from one's own shores, without the necessity of land bases for air elements. A power projection capability may serve national interests at all points of the spectrum of operations. One such recent example is the Royal Navy's use of the carrier HMS *Invincible* in *Operation Bolton* to support United Nations Special Commission (UNSCOM) inspectors charged with WMD monitoring and elimination in Iraq. 'They used the sea as an unhindered highway and threatened the use of force at a time and place of political choice.'[14] If a navy is to remain competitive as a naval power then it must at least possess elements of aerospace sub-capability. This is seen in the RAN order of battle and the majority of other medium navies that possess limited but effective aerospace capabilities. As recent history has demonstrated, the utility of aerospace power has made its use necessary.

The argument in support of aerospace power is in no way meant to diminish or to replace the contribution that land and sea power capabilities can provide to the spectrum of warfare. *The Fundamentals of Australian Aerospace Power* openly recognises this, where Services 'will lead but not monopolise any dimension of the battlespace.'[15] On the contrary, aerospace power is but one important element of the three arms of military power. Aerospace platforms will also always need support from either the sea or shore to operate. Importantly, in military operations aerospace power can be operated complementary to or independent of land and sea power, and this is one area from which it derives its greatest strengths—mobility unconstrained by geography.[16] The political and military advantages conferred by the contribution of aerospace capability to the spectrum of joint military operations is now widely accepted, and the capability land and sea forces are attempting to replicate as core capability within their own order of battle.[17]

The context of the RAN's current force structure and capabilities is reflected in the importance of aerospace power to a medium navy. A medium power may be defined as one which 'has the capability to exercise some autonomy in its use of the sea.'[18] The RAN is understood to be a medium power under these conditions, and this will not change during the time period being examined. Ultimately, as a medium power navy, the RAN must operate and acquire its capabilities within the fiscal and strategic constraints that such a classification presents. As a medium navy the RAN has limited means to project the variety and volume of the combat power it may wish, but it can nonetheless do extremely well with what it has to defend, or threaten force as required against a possible aggressor.

The ADF's *Force 2020* and *Future Warfighting Concept* (FWC) documents, and more specifically the RAN's *Plan Blue* outline those areas where the ADF and RAN respectively will seek to take steps toward 'addressing the challenges and uncertainty of the future operating environment.'[19] Defence plans to generate a 'Seamless Force' that is beyond just joint, conducting 'network-enabled operations,' with an 'effects based approach.'[20] The ADF's future warfighting concept will use these principles to wage 'multidimensional manoeuvre' warfare, using indirect approaches to defeat an enemy using the 'intelligent and creative application of effects against the adversary's critical vulnerabilities.'[21] To this end the RAN is attempting to address the requirements of these changes through *Plan Green*, the Navy ten year plan, and *Plan Blue*, a plan that covers the ten to thirty year period.[22] To do this will take investment focussed on resources and training, and updating of clear goals within these defined plans. These keystone future capability plans, allied with Maritime and Aerospace doctrine, give the Navy the guidance and capacity through which it should be able to raise a credible and effective aerospace power capability.

One large area that permeates *Plan Blue* and the FWC is the concept of the Revolution in Military Affairs (RMA), a generic term that encompasses all the elements of warfare that are directly attributed to the advent of the information age. One key area is Network Enabled Operations,[23] where individual platforms become nodes of a larger network, sharing information seamlessly to provide superior battlespace awareness.[24] Information sharing is the key to these operations, dramatically reducing engagement time through maximising the speed and quality of information available to commanders. The technology of these advances will be discussed later, suffice to say that these technologies are defining the improvements in capability that will shape the future military force structure environment.

Operations in Afghanistan, Iraq, and even the September 11 attacks against the US have all demonstrated the new tenet of Effects Based Operations (EBO). 'EBO is defined as the application of military and non-military capabilities to realise specific and desired strategic and operational outcomes in peace, tension, conflict and post-conflict situations.'[25] Instead of simply striking a target, the effects of the action will be placed in context against outcomes and how this impacts upon achieving the political aims, the result of which does not always even require military action to have taken place. The importance of EBO for the ADF lies in the fact that it 'is more about a way of thinking and planning, and therefore about training our people, than about technology alone.'[26] This is an important factor when military capability acquisition is to be considered, where EBO can provide advantages that a smaller force structure and range of capabilities available may not have historically done.

Targeting is a key issue for EBO. Where superior intelligence, precision strike and clear battle damage assessment are required, the utility of aerospace power has adequately been demonstrated to date, where 'the RMA has found its most potent expression in aerospace based weapons systems.'[27] This will no doubt remain the case in the future, but it does not render sea power obsolete. As discussed earlier, the unique advantages shared by aerospace and sea power characteristics in joint operations will provide the Australian government with flexible capabilities with which to conduct EBO.

The littoral environment is another trend in present spheres of military debate that is predicted as having a marked effect on military thinking. The littoral may be defined as 'those areas on land that are subject to influence by units operating at or from the sea, and those areas at sea subject to influence by forces operating on or from the land.'[28] With approximately 70 percent of the world's and in excess of 95 percent of South East Asia's populations living within 150km of the shoreline,[29] the effects that maritime force projection could possibly achieve within the littoral are immense. Power projection in the littoral is becoming a focus of ADF capabilities, with even the Army taking an 'outward strategy' that focuses on littoral warfare for its *Future Force*.[30] It is within the littoral that the ADF may operate, and it is aerospace and maritime power that will provide some of the most significant military advantages in this environment. For the RAN to remain a credible force to operate in the littoral, it needs to be able to both project and defend against elements of aerospace capability.

For the RAN, aerospace and sea power cannot be considered as separate elements of combat power, and each must be developed concurrently if the Navy is to 'fight and win in the maritime environment as an element of a joint or combined force.'[31] To assure this, the RAN needs to build a robust force of ships and organic air assets, and to develop a joint operational outlook. Equally relevant to any force it may build, it must be understood too that any potential aggressor will use aerospace power against the RAN, and this threat must be countered as well.

The Technology

Present developmental and predicted future technologies are driving a great deal of change in the international security environment. With new technology comes the potential for new or improved capabilities, which then leads to the evolution of doctrine and 'power' applications. Technology does not equate to success, nor does it equate to power itself. The capabilities that evolve from the advancement of technology and their application to the overall force are what provide the military superiority that is desired. Importantly, capability and technology are mutually beneficial for the progress of military power; capability requirements can 'pull' technological change, but technological innovation may also 'push' ahead and enhance capability.

The acquisition and sustainment of a robust aviation capability is a serious challenge that the RAN is facing. Aerospace power can provide superior capability to combat arms, but advanced technology, as with any capability acquired for any of the three services, can be very costly to raise and sustain. The statement 'aerospace power is a product of technology, and it is inevitable that technological advances will affect its development'[32] succinctly outlines the relationship that technology and aerospace power shares. With this perspective over the last century, it is clear to see how technology and aerospace power advances have parallelled the rapid advance of doctrinal thinking. Aerospace power, of the three arms of military power, may be considered the 'darling' of the technological age. This can be seen in the importance placed on aerospace power by the RMA. As important as aerospace power is, its legend must still be tempered, being but one element of a holistic military response to political needs.

Force 2020 recognises the benefits derived from technology. 'We must continue to exploit superior technology to maintain our status as a highly capable defence force', with a 'technology bias' in our capability to complement our economy, large geography and relatively small population.[33] The most important statement in this section of *Force 2020* emphasises the caveat the ADF places on the importance of technology to military power:

> Our strategic advantage will come from combining technology with people, operational concepts, organisation, training and doctrine. We must be careful to ensure that technology does not give an illusion of progress- we cannot afford to maintain outdated ways of thinking, organising and fighting.[34]

In addition to the development of doctrine and the capability itself, this statement introduces the importance of people in the equation of military capability. To this end it is clear that:

> New technology does not revolutionise warfare. Rather technology's impact on systems evolution, operational tactics, and organisational

> structure is its true advantage. This fuels necessary and complementary changes in doctrine and organisational structure.[35]

An efficient and effective aviation force within a Navy is vital, but also costly. Advanced experimental and unproven technologies carry risks, and these risks are compounded by the distance of the time when they may actually be employed as elements of combat power. If the RAN is to remain competitive as a sea power it must maintain a strong aviation capability.

One final general point concerns the dominance of the United States in the international arms industry—the driving force behind the majority of the high-end technological research—and the development of new capabilities. The US presently spends more on defence than the next ten countries combined, and is assessed as 'unlikely to lose its technological edge for many years.'[36] With the end of the Cold War the US remains the world's only superpower, and its whole industrial defence mechanism remains the largest driver for change. Though the US may have the money and the industrial capacity to lead the world, it cannot hold a monopoly on ideas. This is an important factor, especially as a number of other countries' defence industries are providing, and exporting, some unique military software and hardware. Australia's Defence Science and Technology Organisation (DSTO) is one such example of an organisation striving for technical improvement and innovation, as are a number of other private indigenous industries, proving advanced technology developments are not in the sole possession of the US.[37] The importance of the US to the international defence industry cannot be understated. The US has the money, capacity and market to exploit its own and other technologies, an advantage that no other nation can presently match. For a nation that places a high credence on our relationship with the US as a close ally, the drivers of interoperability will therefore grow more naturally from US origins than would necessarily occur from other nations. The Australian government recognises the importance of our relationship with the US as a 'national asset,' whereby 'Australia's defence capability is enhanced through access to US information and technology.'[38]

The elements of technological advancements to be discussed may be broken down into a series of general areas. Firstly, which will influence both aerospace and sea power capabilities, is the area of software and system networking enhancements that 'unify' elements of combat power within the battlespace. Secondly, a study of aerospace technology will cover those salient advances in the area of atmospheric and space flight. Thirdly, enhancements of sea power capability will be discussed in areas of sensor and platform design. Finally, the area of weapons and munitions technology, looking at conventional and 'exotic' weapon developments. This study will aim to outline improvements in all these areas that are related to aerospace power projection within the maritime and littoral environments, as elements of organic sea based capabilities.

Computer software and hardware innovations are possibly the most important aspect of technological advancement. As integrated computing power has traced exponential processing growth,[39] computers are providing the key technology to capability advances. Information processing, management and dissemination between warfighting elements have seen the most significant capability enhancements to result from the RMA. The 'observe, orient, decide and act loop' (OODA loop)[40] is the pure definition of the military decision making cycle, and this is where information based technology is trying to provide the greatest military advantage. Network Centric Warfare (NCW) is the response to this challenge.

NCW is 'not about technology,' but is 'an emerging theory of war.'[41] Technology is however the driver and enabler of this capability. NCW is 'a concept of operations that generates increased combat power by networking sensors, decision-makers and shooters to achieve shared awareness and synchronised activity.'[42] The result is 'increased speed of command, higher tempo of operations, greater lethality and increased survivability,'[43] all 'predicated upon the ability to create and share a high level of awareness and to leverage this shared awareness to rapidly self-synchronise effects.'[44] NCW enables shared and heightened awareness within the battlespace covered by its sensor network. Against traditional vertical information filtration methods that move information up and down, NCW distributes information 'in every direction' to all users on a network. Open architecture software[45] design allows the construction and update of complex NCW systems economically and rapidly within a widely distributed force sharing the information network. The importance of this technology to joint warfare cannot be underestimated. Joint operations will grow stronger as a result, and the ability to prosecute EBO will be immensely enhanced.

A NCW technology being developed by the United States Navy (USN) and the Royal Navy (RN) is the Cooperative Engagement Capability (CEC).[46] CEC combines a high-bandwidth communications network with a powerful fusion processor to enable real-time distribution and fusion of sensor information from all CEC-equipped units, so that cooperating platforms create and share composite combat system information on targets and can function as an integrated air-defence network.[47] Though information can presently be shared via tactical information data links,[48] target identification and fire control quality information cannot be passed between the services.[49] The project aims to counter increasingly fast and lethal integrated air-defence systems, and to grow by gaining the capability to identify, locate and destroy time sensitive targets.[50]

A key feature of any network-enabled system is the sensor 'constellation' that will feed it information. Though networks are not meant to rely upon critical nodes, they do need a wide number of sensor types and platforms to gather the information required. The concept of intelligence, surveillance and reconnaissance (ISR) is underpinned by the presence of capabilities to gather this information, and is vital for the success of initiatives such as the US Global Strike Task Force (GSTF).[51] For success in modern warfare to be effective, the location of sensors, the detection, tracking and targeting of the adversary, and the rapid application of force against these, all is driven by real-time location feeds.[52] A constellation of manned, unmanned and space sensors can provide the battlespace coverage required, but can be inhibited by bandwidth limitations. Video, voice and data streams of information transferred between all nodes of a network, continuously requires processing equipment 'orders of magnitude better' than those provided by conventional datalinks.[53] NCW networks that need to operate outside of the constraints of terrestrial line of sight sensors will also present a technical challenge to get the datalink space based, providing constant global coverage,[54] but at an almost prohibitive cost for smaller powers.

As can be seen from the NCW sensor constellation, aerospace power has asserted itself as the key enabler of this type of capability. One of the most exciting areas of growth in recent times has been the uninhabited air vehicle (UAV) and uninhabited combat air vehicle (UCAV). UAVs themselves are not new, with the first camera equipped remotely piloted vehicle tests performed by the *Luftwaffe* in 1939.[55] They have been used in a number of conflicts such as Vietnam, the Gulf War and the War on Terror by the US, and frequently in operations by the Israeli defence forces. After a series of failures in ventures such as DarkStar in the 1990s the UAV has begun to regain favour as a valuable aerospace capability. The key point with UAVs now is that the advances in technology surrounding their own development and the payloads they carry has created a capability enabler, and not simply a remotely piloted platform.

Why are UAVs and UCAVs gaining so much attention? The very nature of the mission capability they provide—persistence, expendability and stealth[56]—exploits those aspects that manned aerospace assets presently cannot. Additionally, the UAV market is 'more accepting of unusual designs' than the manned aircraft industry,[57] giving manufacturers the ability to provide innovative and economic solutions to some complex capability requirements. The General Atomics RQ-1 Predator UAV is a good example of UAV evolution. From a propeller driven UAV surveillance platform the Predator became a tactical UCAV when it had Hellfire missiles 'strapped' onto it, and gave the US government a covert and persistent attack capability in its war on terror.[58] After the successful attack by a Central Intelligence Agency Predator against six suspected Al-Qaeda operatives in Yemen the platform gained more attention for sensor and performance enhancement,[59] and was even under evaluation for Stinger missiles for self defence.[60]

The uninhabited platform is desirable to military planners as it allows air operations to continue in environments where there may be unacceptable risks to inhabited platforms. For this reason UAVs have drawn support and criticism. One specific role of the UCAV is the suppression of enemy air defences (SEAD), where complementing manned aircraft by going into places that piloted vehicles cannot is seen to add value. For some air planners, 'if they can't do that, then I would recommend not investing in them.'[61] Noted air strategist Colonel John Warden (retired) has gone to the point of predicting that by 2020 US combat aircraft will comprise 90 percent UCAVs, with manned missions retained to solve the 'complicated shoot/no shoot decisions on the spot.'[62] Initially though, it is clear that the key to UAV capability in an integrated force is not replacing manned flight, but augmenting it.

The roles envisaged for UAVs are numerous. SEAD, tactical and strategic ISR, and chemical, biological, radiological detection roles are often cited. The technology available sees platforms such as Global Hawk or the Boeing X-45A demonstrator performing such roles now. The future sees numerous advances in technology and operational employment for more sophisticated UAVs. A bigger X-45 UCAV family that can swarm in multi-ship formations will satisfy many missions deemed too dangerous for manned aircraft.[63] A Lockheed Martin concept for a multi-purpose air vehicle stored in a Trident submarine's ballistic missile tube that can be launched, controlled and recovered all whilst submerged is under development.[64] A SensorCraft of a 'sensor-centric' design whereby the whole platform is one big sensor suite complemented by a 60 hour endurance may be the platform with enhanced capability to replace the Global Hawk.[65] Micro UAVs such as the DARPA Black Widow, which at less than 15cm long, can fly to 800ft and provide real-time colour video downlink for 30 minutes will support ground troops and special forces in combat and surveillance situations.[66] The Low Cost Autonomous Attack System (LOCAAS), a UAV designed and tested to fly up to 100 miles into the battlespace, loiter, and detect, track and engage targets autonomously is an initial SEAD capability in high threat environments.[67] The potential capability enhancements provided by the UAV have not been lost on the international community, where the UK, Italy, Germany, France Spain, Sweden, Israel and Australia are examples of countries pursuing joint or independent UAV development programs.

Traditional manned aviation is also seeing a number of technology-driven advances that are enhancing aerospace capability. The F-22 *Raptor*, F-35 Joint Strike Fighter (JSF) and the F-18E/F *Super Hornet* comprise the US three-fighter plan for the future, where the F-22 and JSF provided a complementary force of 'high-end' and 'low-end' capabilities respectively.[68] These two aircraft will be the most advanced platforms of their kind, employing networked sensors, a variety of precision munitions, and low observability (stealth) design concepts. First operational in 2005, F-22s are envisaged to join B-2 bombers as part of the GSTF in first entering hostile battlespace and clear it for successive waves of strikes. Though the USAF will be the only user of the high-end F-22, the JSF will be the future 'low end' platform used by the US and coalition countries as the workhorse combat element of aerospace capability. For Australia, the decision to replace the F-111 and the F/A-18 with the one airframe under the auspices of AIR 6000 is a large and significant step that will drive the direction of ADF combat aerospace power for the 20–30 years of its service life. The JSF provides flexibility of land, carrier or short take-off/vertical landing (STOVL) options, superior sensors and capacity for a variety of advanced munitions on internal and external hard points on this stealthy aircraft. Which version the ADF purchases should be placed under close scrutiny. The UK Ministry of Defence's decision to purchase the STOVL version aims to 'future proof' the platform, as comparison between variants sees minimal variation in performance.[69] The US Marine Corps (USMC) has also selected the STOVL JSF, considering the platform 'essential for the vision of where we are going—it is pivotal for the expeditionary mission of the USMC.'[70] The RAN will see the direct influence of JSF on ADF aerospace power when it enters service around 2012, and JSF interoperability issues will no doubt drive a number of capability enhancements.

Other capabilities of direct influence within the maritime battlespace are maritime patrol aircraft (MPA), helicopters, and command and control (C2) platforms. The role of the MPA has expanded significantly since the Cold War, shifting from primarily anti-submarine warfare (ASW) to wide area surveillance, anti-surface warfare (ASuW), electronic intelligence gathering (ELINT) and maritime strike.[71] Such capabilities simply cannot be discarded, though some technologies such as UAVs could augment some of these roles. Most present programs for capability enhancement are aimed more at upgrading mission systems than airframes.[72] As airframe obsolescence creeps on, the next generation of MPAs will in all events be supporting the ADF's missions over the period 2020 to 2030. Not too detached from their origins, new Western MPA platform proposals come in the shape of modified commercial Boeing 737s and Airbus A320 aircraft that will sport up-to-date mission systems and munitions packages to suit primary and expanded roles.[73] Tied in to the earlier discussion of improved communications and software technology, open architecture systems as part of a networked force is where the MPA will see the most change.

The naval combat helicopter is also seeing an evolution that is being driven by 'software' rather than 'hardware' improvements to increase capability output. The USN Helicopter Master Plan will see the introduction of the two 'lynchpin airframes' in the MH-60S combat support helicopter and the MH-60R multi-mission helicopter.[74] An evolution of the Sikorsky H-60 stable of platforms like the *Black Hawk* and the *Sea Hawk*, these new platforms offer a far greater range of capabilities, with the advantages of a reduction in platform type and possibly in platform numbers. The MH-60S is the 'truck', being the platform for combat support, airborne mine countermeasures, combat search and rescue, and Special Forces (SF) operations in the littoral. The MH-60R is the 'high-end' version, becoming the tactical helicopter supporting surface combatants and aircraft carriers on the high seas and in the littoral battlespace by fusing optical, electronic, radar and sonar sensors all within the helicopter's own airframe.[75] The commonality of airframes provides logistics and training dividends, whilst sensor and software suites give each of the two types a unique set of capabilities from which they can fulfil their roles. Not dissimilar to Australia's own AIR 9000 ADF Helicopter Strategic Master Plan project, the USN Helicopter Master Plan is looking to economise by reducing the physical platform differences within the fleet, without losing the broad spectrum of capabilities differing platforms possess.

Another capability type that will develop along lines similar to the MPA is the C2 platform. The E-3 Airborne Warning and Control System (AWACS) and the E-8 Joint Surveillance Target Attack Radar System (Joint STARS) are two vital sensor and C2 platforms within the battlespace.[76] The future is presently driving these capabilities into a single platform dubbed the Multi-Sensor Command and Control Aircraft (MC2A).[77] An advanced electronically scanned array radar will be the primary sensor, a technology that allows the two platforms mentioned above to be replaced by one that can monitor both the air and surface battle spaces. A battlespace management command, control, communication, computers, intelligence (BMC4I) system is the 'brain' of the information processing and dissemination systems, enabling use of all other sensors within the network-enabled constellation—ground, air and space based. With the ADF's airborne early warning and control (AEW&C) capability soon to come on line, by the period 2020 our platforms may be operating with the MC2A as part of a network enabled force. The key point to note here is that although the platforms will not perform nor look entirely different in a physical sense, the technology involved in the MC2A's sensor, processing and communications packages may be a quantum leap, thus offering a real capability advantage.

Lighter than air platforms are also evolving, offering good persistence and geographic coverage at a markedly smaller cost compared to satellite based systems. Though high altitude balloons are hard to control, their relatively small cost, high operational altitude and a recoverable payload in some cases of up to 2,700kgs offer a number of advantages to a military user.[78] Military applications for Tethered Aerostat Systems[79] and other airship designs are being developed by the US Army to carry sophisticated radars for surveillance to counter potential cruise missile threats against the US as part of their Homeland Defence strategy.[80] Offering cost-effective persistency, lighter than air systems offer many capability options in the future maritime battlespace.

Underpinning many of the advances in sensor and communication constellations that allow a network enabled terrestrial force is a wide variety of space based systems. Satellite systems are not new to military applications, but the extent upon which they will be relied and the information they will carry is where the utility of their capabilities will be found in the future. Space based optical, laser, infrared, radar, communications and electronic intelligence gathering systems are evolving in support of military operations. Their advantage is not that they necessarily carry a unique payload (for a simple UAV could perform a number of these tasks), but they are a global system with an endurance that cannot be matched.[81]

The information to be networked by a constellation of many sensors across a broad range of the electromagnetic spectrum in real time around the planet presents significant bandwidth and technical dilemmas in a network enabled environment. Present and predicted computing technology is helping make this happen, but innovative approaches to systems management of space assets may also draw dividends. To meet satellite imagery demands for military and government uses, commercial assets are widely used. Even the US is opting to extensively use commercial satellite imagery,[82] filing the gaps that cannot be met by the demand on present systems. Technology management of space assets and sustainability through the transition from individual platform 'programs' to 'architectures' of networked systems under the Transformational Communication Architecture (TCA) is the US solution.[83] Standardising assets and simplifying sustainability of space based assets is hoped to give military forces a space based 'internet-like' communications system by 2015, allowing enabled units the ability to join and leave the network as required, all supported by the advantage of the satellite's global, enduring coverage. As the technology becomes more heavily relied upon, physical anti-satellite systems, or electronic warfare and jamming measures will proliferate to counter space based systems. As the technology advances and is exploited in the space environment, it follows that war will have to be fought in space too.[84]

Advances in technology affecting maritime platforms and sensors will also have an effect on the shape of aerospace power in the maritime environment in the period 2020 to 2030. Evolution in ship design can bring flexibility in a range of capability options. With aerospace platforms based, operated and controlled from the sea it is important to consider the impact advances in maritime technology will have on aerospace capabilities.

Multi-hulled vessels like the UK's *HMS Triton*, presently being trialed, are helping to develop innovative and capable maritime platforms. With three hulls such a design offers far greater deck space for aviation operations, and the benefit of a shallow draft that is of great benefit in the littoral environment. The US Army is trialing a wave piercing catamaran platforms in the form of the HSV-X1 *Joint Venture* as part of its Theatre Support Vessel (TSV) program. A TSV with high speed and shallow draft design offers the performance to 'deliver a complete unit' fuelled, armed, armoured and with its command and control element into the theatre of operations.[85] The TSV is envisaged not as a replacement for aircraft delivery of these elements of combat capability, but to complement the role of the C-17 or C-130 in intra-theatre support, giving US planners sea, air and land delivery options.[86]

Other technologies are also driving ship design ahead. The USN competition to field a Littoral Combat Ship (LCS) will see a highly capable platform fight as part of a networked force within the littoral. Amongst other systems the ship will be designed to operate helicopters (including the MH-60R), but also rely on tactical UAVs, unmanned surface vehicles, and unmanned underwater vehicles as part of a networked force.[87] The projected sixty LCS platforms to be acquired will greatly enhance the USN's ability to provide a combat force within the complex littoral, and fight those threats such as diesel electric submarines, mines and swarming attack craft that are envisaged as threats in this environment. The USN is looking heavily toward northern Europe for ideas and technologies for the LCS,[88] where platforms such as the Swedish Navy's *Visby* Class stealth corvettes are coming into service with new and advanced hull design, construction and low observability advantages.

One of the biggest drivers in surface ship design at present is the concept of 'modularity', where the design of the ship may accommodate a number of changes, thus changing the capability with minimal difficulty. The 'plug-and-play' design principle is demonstrated today on the Standard Flex 300 design of the *Flyvefisken* class in Denmark's patrol forces. The platform's hull and engineering spaces remain the same, but three 'voids' in the deck may be filled with a mix of systems to fulfil roles as varied as mine countermeasures, ASuW attack, mine laying, and ASW, to hydrographic survey and pollution control.[89] Such a platform that allows for a variety of different capabilities, yet only rotating the trained personnel needed to operate this equipment within the crew, offers a great deal of flexibility. The multirole vessel (MRV) concept being pursued by navies in Europe and New Zealand, offer Stanflex based designs that can provide flexible capability in the one platform to suit their diverse needs.[90] Upgrading equipment, training specialists and incorporating new systems requires less effort, may be incorporated rapidly at almost any port, and with little need to change the mindset of those operating a system that has flexibility built into it. Such a design feature may well become the norm in the future.

The introduction of Standard Flex design principles, allied with the Vertical Launch System (VLS) of sea based ordnance is now offering navies greater flexibility. The VLS is employed by many world navies and offers inherent flexibility in its multiple cell modules. Each cell can contain a variety of different munitions to cover the spectrum of military capabilities necessary for designated operations. Weapons and cells can be upgraded as required without expensive ship refits and flexibility for improved systems to be integrated in the future. This concept may not appear to be anything new for aviators. With multi-role aircraft sporting weapons rails and hard points that can hold an array of different ordinance, air forces have long offered the commander a flexible capability. The 'plug-and-play' modularity of the LCS will give it greater flexibility for upgrade and mission employment through its service life.[91] VLS systems will give ship designs such as the USN DD(X), CG(X) and LCS family, and European designs like the MEKO D and MEKO X future surface combatants a flexibility of ordinance packages for a variety of missions. Some of these designs also include independent weapons, sensor and combat systems separated fore-and-aft to increase survivability in the event of battle damage. Such flexibility will allow navies to tailor their ships to meet the needs of the mission with the requisite capability, not only a requisite platform.

Aircraft carrier design is possibly the most evident example of the way that ship design will affect future aerospace capability in the maritime environment. US and UK designers are hoping to leverage many new technologies in the construction of the next generation of aircraft carriers. The UK's next carrier is designed to be 'future proof', with a 'fitted for but not with' design philosophy.[92] Given the UK operation of *Sea Harriers* and the decision to purchase the STOVL version of the JSF the future appears relatively clear for the next two to three decades of Royal Navy carrier aviation. The whole future proof concept for the two platform carrier purchase is looking out fifty years, a reasonable estimate for the life of the carrier, with the design allowing for future inclusion of catapult and arrester systems if required. For a more advanced 'medium' navy the UK approach is sound, attempting not to inhibit future capability options with the acquisition of a limited capability now. Such design concepts will no doubt drive many medium navies' aircraft and helicopter carrier forces over the next few decades.

The zenith of sea based aerospace power projection, the USN aircraft carrier, will see some dramatic design changes over the next decade. Electromagnetic aircraft launch and recovery systems, a bigger flight deck, an integrated warfare system, improved deck ammunition handling, a new engineering plant and new procedures are all aimed at streamlining and optimising aviation operations.[93] The program, dubbed CVN-21, also incorporates elements of future proofing, with an integrated power system designed to incorporate any future electric weapons onto the ship when developed. The first CVN-21 aims to deliver more combat power volume with half the crew and at half the maintenance cost, all for deployment by 2014.[94]

Uninhabited underwater vehicles (UUVs) are also introducing new capabilities for the future maritime battlespace. The aim of the UUV is to extend the reach of manned platforms, operating autonomously for extended periods, and often in environments that would be too dangerous for manned platforms.[95] The UUV role is therefore similar to those of the UAV. The main capabilities identified in the USN's April 2002 UUV Master Plan include undersea search and survey (including mine hunting and hydrographic survey), communications and navigation aid, submarine track and trail, and maritime reconnaissance.[96] UAVs are also in the process of development as a submarine payload in the Multi-Purpose Air Vehicle (MPAV). The MPAV is to have a stealthy design, carry a 454kg modular payload, and like the UUV is designed to be launched and recovered by a submerged submarine.[97] UUVs and UAVs integrated into USN nuclear submarines aim to bring about a "significant transformation" in the clandestine force,[98] maintaining the submarine's relevance and the diversity of capabilities they may employ. With the first UUVs to be in service by December 2004 and UAVs later, their operational use will reinforce the importance of the submarine as a covert capability unique to the maritime environment.

Advancing technology is also providing more potent capability through the improvement of weapons deployed by both aerospace and sea based platforms. One of the most important weapons to be fielded in the future is an evolved array of cruise missiles. An insightful observation that the US 'used to have gunboat diplomacy, now we have Tomahawk diplomacy'[99] demonstrates the importance of these strike weapons. Launched from the air, land, and sea or undersea, the cruise missile has the ability to precisely strike targets at long range, providing a unique and powerful strike capability. Used in all major conflicts since the 1991 Gulf War these weapons are evolving and proliferating. Cruise missile technology is integrating datalink to the weapons, allowing them to be updated with new information whilst in flight, and with infra-red imaging terminal seekers to destroy precise targets identified previously by intelligence sources.[100] Cruise missile capabilities are predicted to include loiter time over the battle area for up to three hours, an ability to carry a number of smaller sub-munitions to deploy over time, the ability to conduct battle damage assessment, warheads that can penetrate bunkers, and others that may travel at speeds of up to Mach 6.[101] The conversion of many 'traditional' anti-shipping missiles such as *Harpoon* into more advanced versions with basic land attack capability are also predicted to become commonplace. The capability of the cruise missile will only expand as technology also expands the performance of these weapons.

The evolution of the anti-aircraft missile is also progressing with the US Standard Missile system leading the way. The USN is upgrading the present SM-2 system to the SM-3, a ballistic missile defence (BMD) variant. The US aims to have 19 of the 66 Aegis combat system, AN/SPY-1 radar equipped, *Ticonderoga* cruisers and *Arleigh Burke* destroyers matched with the SM-3 missile to defend US and coalition assets against ballistic missile threats within their area of operations by 2005.[102] Such systems are the object of intense debate throughout international circles, but if the technology is fielded, ships thus armed have the potential to neutralise any air threat within the battlespace, as well as being able to provide important BMD for a naval or land based force within its coverage. Such a capability may be the norm and not the exception by 2020.

Naval gunfire systems are also advancing. The fire support mission remains the key driver of technical improvements, with many European navies opting for multi-mission guns that provide a land attack capability.[103] Greater accuracy and reach are significant measures of naval gun improvement, with the 12.6nm range of today's 5 inch gun ammunition being surpassed dramatically to a range of 54nm by one product in trials to date, and lesser but still significant distances by other new rounds.[104] Future naval gun systems are increasing to 155mm calibre and the range of the gun and ammunition combinations that fire projectiles out to 100nm with mid-flight guidance updates should be in service between 2007 to 2012.[105] With the increased need for littoral operations perceived in the future, such systems would be important to the support of ground forces. To effectively field and operate this capability, a heavy reliance on good intelligence in the target area will develop, and associated aerospace capabilities will be in an excellent position to provide this.

Aircraft-delivered munitions are also advancing at a fast pace, with precision guided munitions complementing the theories of effects based operations. Technological improvement of air launched ordinance is making strikes more accurate, with a deliberate application of the right destructive force for the target chosen. The advantages conferred by their use and technical improvement are significant and will continue to be into the future. USN carrier air wings were estimated to be able to strike 200 targets daily in 1991, and now a wing may strike up to 700 in the same time period.[106] Guided munitions are now the norm and not the exception in an air campaign.[107] During the war in Iraq the *Hellfire* range of air launched missiles saw different variants tailored to strike different targets. Employed to destroy tanks and bunkers, one model was designed where the blast was contained within a single room of a building to destroy targets in urban environments whilst minimising collateral damage.[108]

Other developments such as the satellite-guided Joint Direct Attack Munition (JDAM) or the Small Diameter Bomb are allowing aerospace platforms to strike any stationary target, in any weather, at any time. The impact of this can be seen when considering that the B-2 *Spirit* stealth bomber may now carry up to eighty 500lb JDAM munitions in one mission, for delivery on up to eighty separate targets spread across 15 miles, each bomb falling within 10m of the target.[109] When the Small Diameter Bomb is employed on US aircraft by 2006, the 250lb INS/GPS guided munition will share all the benefits of the JDAM's precision and firepower, whilst doubling the amount of ordinance a single platform can carry.[110] The B-2 as an example may then be able to deliver 160 munitions onto 160 different targets near simultaneously. Technology will continue to improve air delivered weapons to meet the needs of combat power, with precision, size and effects orientated destructive power the focus of change.

The combination of networked sensors and precision guided munitions is leading to solutions for one of the hardest targeting questions—hitting a moving target. The US Affordable Moving Surface Target Engagement (AMSTE) program networks two sensor platforms to detect and track the target, generates a firing solution in the control aircraft, and passes this to a third platform to launch an inexpensive unguided munition to destroy the target. Trials to date have destroyed single and multiple targets, on their own or in convoys respectively, with another series of trials later this year attempting to track and destroy individual targets in traffic.[111] US Air Force Secretary James Roche commenting on the war in Iraq (and possibly drawing on the lessons of Kosovo) has identified that mobility will be essential for future adversaries, because presently if a target 'is in a fixed position … we just obliterate it.'[112] Such is the importance placed on the development of the technology to destroy mobile targets that the think-tank RAND believes that without such a capability U.S. operational and strategic goals 'are unlikely to be met.'[113] Aerospace power offers the flexibility and presence needed to enable this advanced capability, a role that land or sea forces cannot.

Finally, a range of 'exotic' technologies offers a number of permutations for the future battlespace. Each would have a dramatic effect on the future maritime battlespace, but each is as yet relatively untried, ineffective or of limited use within current technology constraints, or on the fringe of development within the timeframe of this discussion. Though all 'on the drawing board,' accelerated advances in development could make them potent systems to greatly enhance aerospace capabilities for the RAN in the period 2020 to 2030.

Technology is advancing to make hypersonic propulsion a viable capability in three main areas: hypersonic strike aircraft; air-to-ground missiles to strike time sensitive targets, and re-useable launch vehicles for more economic space access.[114] Powerplants may include ramjets, supersonic combustion ramjets (scramjets), or pulse-detonation engines, offering speeds between Mach 5 to Mach 12. In cruise missile form hypersonic weapons could reach targets on the ground after release from hundreds of miles away in only minutes, with enough kinetic energy to destroy targets and even penetrate bunkers, thus obviating the need for large amounts of explosive.[115] USAF Research Laboratory studies are presently looking at this technology with an availability from the year 2010 onwards. The advantages of such weapons will not be the sole preserve of aerospace platforms. As hypersonic propulsion evolves its application will also be relevant to ship launched land attack and anti ship cruise missiles, in addition to surface to air missiles.

Beam weapons, although in the developmental stage, are also predicted to make a dramatic impact upon combat power when developed to their anticipated potential. Separate to some advanced traditional gun technologies[116] high power microwave (HPM) and charged particle beams (CPB) are presently under investigation. HPMs use RF energy against electronic systems, disrupting or destroying electronic circuits within any type of electronic device around a targeted area. The HPM emission affects an area larger than a single traditional explosive munition could, attacking any electronic equipment within such an area and reducing or destroying its ability to function, yet not damaging humans or physical structures.[117] Though a number of technical barriers are yet to be removed before widespread acceptance of the technology occurs, experimental development of a weapon has been achieved by the USAF, with proponents of the technology seeing widespread application of HPMs on UCAVs in the SEAD role. CPBs utilise a beam of particles travelling at close to the speed of light to directly or indirectly destroy target objects. Such weapons have been the object of military research since 1974, but have not yet proven physically viable.[118]

Laser weapons are well developed, and though relatively limited in capability, can potentially satisfy a wide variety of military applications. The USAF's Airborne Laser (ABL) program is developing a megawatt-class chemical laser on a Boeing 747 platform to destroy boosting ballistic missiles out to a range of 321 kilometres, and with sensor and software developments may also counter other airborne or ground targets.[119] The planned scope of laser weapons beyond platforms of a 747 sized platform tends toward much smaller aircraft such as AC-130 *Hercules* gunships, the JSF and UCAVs. Chemical, electric (or solid-state), and free electron lasers range from viable to highly experimental respectively, but could offer a capability in the neutralisation of machines and electrical equipment using a virtually unlimited 'ammunition' supply, whilst being operated from land, sea and air. The USAF will trial shooting down a ballistic missile with the ABL around 2005, the US Army will field a vehicle-based laser system to test defence against artillery and rockets in early 2004, and the USN is developing similar systems now.[120] With operational lasers likely by the end of the decade, such weapons may well be commonplace by 2020, and form an important component of aerospace capability.

A variety of other advanced weapons systems are under development. The 'electronic ballistic' weapons being developed by the Metal Storm company sees capabilities as varied as close-in ship defence systems to weapons packages on airships that can destroy cruise missiles.[121] The US is working on a series of 'sleeping' or 'hiding' weapons that are deployed into enemy territory that attack using smart weapons when told or triggered to do so at a later time.[122] 'Shape-memory' metallic alloys, which change shape under different electrical charges, offer enhancement of aerodynamic manoeuvrability and a reduction of drag on many aerospace platforms.[123]

Improvements in technology cannot be ignored when considering aerospace and maritime capability. The ADF will use new technology, operate with allies who have it, or operate against forces that use it. Therefore the RAN needs to stay abreast of technical innovation, and take what improvements it can and integrate them into a modern force—the 'push/pull' technology/capability relationship cannot be ignored.

The Capability

Capability itself can be hard to quantify, and must be considered in quite a broad context. Capability is not simply platforms. The FWC sees ADF capability as the combination of joint task forces and preparedness,[124] but it can be best defined by examining Figure 3. The essence of capability is the balance between force structure, people, preparedness and sustainment over the life of the capability. If the capability equation is to derive positive results, a balance must be struck between each of the elements of which it consists. Having a strike capability could seem potent with an aircraft like the JSF, but such an assumption would be incorrect if logistic support was haphazard, pilot ability was poor, or the munitions they deliver were of an inferior or outdated design. Capability is effective only if each element leads to form a balanced whole.

It becomes evident that capability, especially of the 'high-end' and complex warfighting kind, cannot just materialise in a short time and provide the desired advantage. On the contrary, capability can take decades to build or 'resuscitate'[125] to a level whereby the equipment is operating reliably and there is a corporate knowledge base amongst personnel who maintain, operate and employ the capability. As mentioned earlier, this is where doctrine and training become so vital in the human side of raising and maintaining a capability. Additionally, throughout the predicted life of a capability there is always the threat that unpredicted events or revolutionary advanced technology may render a system obsolete.[126]

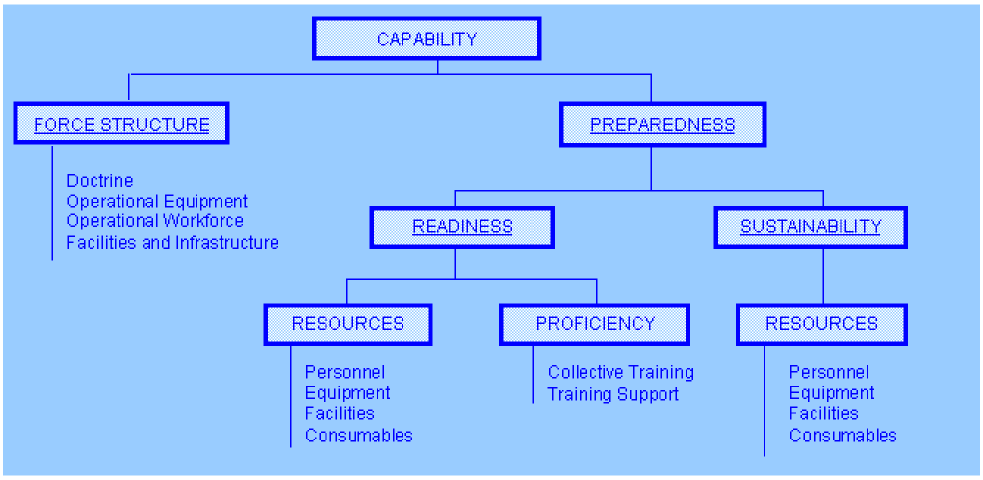

Figure 3: The Components of Military Capability[127]

The purpose to which a capability is put can be changed much more easily, and is inherent to the flexibility provided by military forces. Figure 4 shows 'The Span of Maritime Operations', all those roles that the RAN may, and many that it has, participated in. Considering these operations, and in the context of the strategic framework discussed earlier, RAN capabilities are selected. Each of those elements satisfies a national objective of the Australian government. To satisfy combat operations, high expense 'high-end', capabilities for use in high-risk environments are required. For benign diplomatic and constabulary operations, such as search and rescue or peace building, less complex, lower risk 'low-end', capabilities are required. Many 'low-end' operations may see the inclusion of 'high-end' platforms that were not necessarily designed for low intensity operation. The inverse is not true, where 'low-end' capabilities could not adequately deal with 'high-end' operational problems. From this a general observation arises: 'high-end' capabilities allow solutions to 'low-end' operational problems, but 'low-end' capability cannot satisfy 'high-end' operational needs.

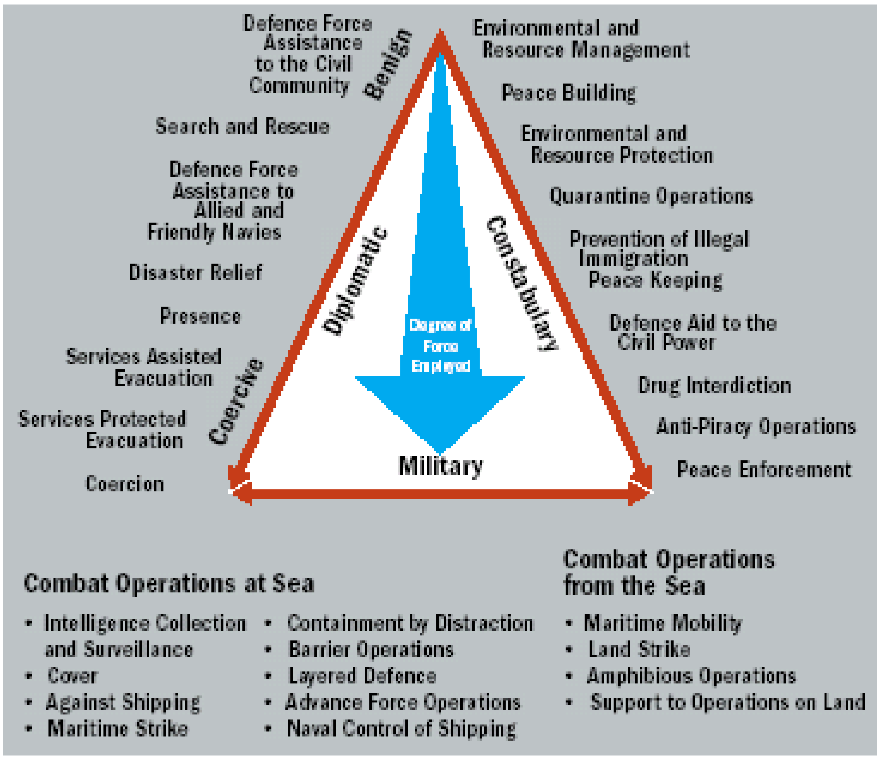

Figure 4: The Span of Maritime Operations[128]

The importance of this capability may be seen in the following examples. The RAN's *Adelaide* class FFGs (modified USN *Oliver Hazard Perry* class), designed as a fleet escort for air warfare piquet duties with a helicopter to hunt submarines, were stationed in the outer screen of layered defence in a carrier battle group during the Cold War. Recently, these ships and their air assets have been employed in the Persian Gulf conducting maritime interception operations against smugglers in support of United Nations resolutions. The point to note is that the FFG, designed for 'high end' warfighting, can do both of the above-mentioned roles, though the constabulary role is not its primary capability. A patrol craft could well do the maritime interception operations successfully, but would be of negligible use if needed to escort ships where an air or submarine threat existed.

'High-end' and 'low-end' capability requirements also correspond to cost, a major factor for consideration in the capability question. For the RAN maritime warfare 'is inherently technology sensitive and capital sensitive.'[129] The more you want a capability to achieve, the more efficient and effective personnel using and managing the capability need to be, and the greater number of platforms you fly or put to sea to satisfy the objectives. All cost an immense amount of money. The US is arguably the only nation in the world that can pursue military capability as it pleases, but for smaller nations the cost of capability is often the biggest factor limiting its existence.

To moderate what the best capability solution for a force is within cost constraints means that a number of serious decisions need to be made. The capability mix of a country is the result of this decision making process. In Australia's situation an individual service may be given exclusive 'high-end' capability enhancement priority, and though part of a joint force, would lead to the erosion of the other two services' capabilities. A force could be produced under the auspices of one of the following three options: a 'high-end' force with only a very limited number of capabilities, a 'low-end' force with many effective capabilities but a limited ability to respond to complex 'high-end' contingencies; or a mix of 'high' and 'low' end capabilities in balance. Though the latter may appear the most sensible option, this may not always be the case. If the national objective places a very high importance on interoperability, then a small, 'high-end' niche force could provide a very valuable capability to an allied force. Additionally, capability acquisition in Australia's case may focus on 'offensive' power projection, or 'defensive' defence of the air-sea gap. Capability will thus mirror the needs of the strategic outlook.

For Australia, the 'high-end' and 'low-end' warfighting requirements that drive capability are well balanced. Capability emphasis becomes evident only when the national objectives—such as the defence of Australia, coalition operations, regional security, and the war on terror—are shifted in order of priority. Thus, the emphasis on capabilities may shift but an objective balance seems to remain. As a medium power, the ability to alter the capability mix to maintain a balance for Australian security is an advantage, but by no means a luxury. Achieving the right balance and preparing robustly for an uncertain future is therefore a significant challenge.

A Viable and Capable Force

To generate the capability to best match Australian national objectives within budgetary constraints is the key challenge for the ADF. To successfully employ a maritime concept of strategy to wage EBO, a variety of 'high' and 'low' end capabilities have and will be raised and sustained to create a comprehensive national response. The RAN needs to develop a wide spectrum of operational capabilities to deal with contingencies in the short and long term, often with little or no prior warning.[130] For the RAN, the complementary nature of aerospace and maritime capability to satisfy ADF objectives will allow this, but the way ahead will by no means be clear-cut, nor will the decisions to be made be very simple. No matter what the future may hold, the future battlespace will still be a complex and difficult environment in which to operate, despite technological offerings.[131] Progress towards the future will require close scrutiny over the next few years, especially if the RAN is to employ enhanced capabilities over the period 2020 to 2030.

An address on the RAAF's future focus by Air Commodore John Blackburn at the 2000 Aerospace Conference can equally describe the core theme underpinning the planning of RAN's capability planning for the tomorrow. Although predictions of what the future will be like are highly speculative, and even in some circumstances 'dangerous,'[132] the importance of the future is in the 'journey'. The 'journey to the future is more important than the predicted destination, for we will have to fight and win whilst we are on that journey and not when we reach the end of the rainbow. We will never reach that end as it will always be ahead of us.'[133] All the Services recognise this and, like the RAAF,[134] each has similarly looked to address the future through a shared 'organisational focus'. Essentially, we don't fight our wars with a future fleet of ships, submarines and aerospace platforms, but with the fleet in being that we have at the time.

The examination of a viable and capable force must reconcile those capability acquisition issues. An organisational focus looking at how the RAN may exploit capability in the future as an organisation and not just by examining the platforms is one of the most important tenets of sensible decision making. The following discussion highlights the key tenets of capability acquisition for the RAN, and some of those technologies discussed earlier, that would have the greatest chance of creating a robust and capable maritime based aerospace capability by 2020. Some of these observations may be shared equally between aerospace, surface and sub-surface capability development, but I will focus on aerospace capability here.

Capability acquisition will need to be effects driven, not platform focused. What the platform needs to do and how well it does it is the key, not simply purchasing a newer version with better performance than the old platform. This is not to say that a platform's type is discounted, for it cannot be, but what it can do is most important. A related factor that will impact on decision making is 'fighting the last war', where capability is improved or acquired to address what was deficient after the last operation. Improvement of forces is important, and innovation cannot be discounted after conflict. This said, the next operational scenario cannot be predicted, nor will it be possible to precisely determine whether the capability enhancements chosen may soundly address any future situation.

Balancing affordability and maintaining the 'capability edge' is a sizeable challenge too. Just because Australia has a medium navy does not automatically mean that the RAN will have 'medium capabilities.'[135] Australia will need to maintain a 'high-end' warfighting advantage for two main reasons—regional superiority and coalition interoperability. Having a technologically advanced force and maintaining it is a challenge, because any capability dates drastically if it is not continually enhanced. Australia needs its capability to be advanced to counter regional proliferation of any one of the number of threats that could eventuate over the coming decades. To this end the ADF will need to maintain a strong and smart force—but affordable.

ADF emphasis on coalition interoperability is a high priority, and understandably so. With contributions to international security through coalition operations as diverse as the East Timor intervention to the recent conflict in Iraq, we may need to operate as a coalition of variable size and capability in the interests of collective security. With the US advancing so rapidly in the area of information operations, the technology to link into the network and contribute is very expensive. This poses a large challenge for the ADF - the more advanced the system becomes, the more prohibitive the price, and the more exclusive the access. Just to achieve high level interoperability in the future with the US and UK, countries like Australia will need to acquire the capability at the expense of other perceived needs. Not being part of an information based system could even be dangerous if not part of a networked 'identification friend or foe' environment. The disparity between the capability 'haves' and 'have nots' is widening, where only those who may receive the benefit of such military advantages are 'financial friends' of the world's only super-power. It will be important for Australia not only to maintain 'high-end' capabilities to meet the needs of our 'high-end' allies, but also to recognise and be capable of operating with many other nations that lack this technology who participate in future coalition operations.

Though the RAN may possess a robust force capability mix for 'high-end' coalition operations or actions in the defence of Australia, much of its time may be spent either in peace or operations other than war. The capability acquired must also realistically address all national security needs on the spectrum of military operations, and not solely combat operations. RAN aerospace capabilities acquired to suit 'high-end' operations will need also to keep providing 'low-end' solutions if the force is to satisfy broad national security objectives.

The ADF must be very careful of capability acquisition risks. Risk management will be vital for future capability decisions, and is evident in three main areas—cost, 'multi-role' platforms and regional stability. The drive to have the world's best diesel-electric submarine in the *Collins* Class was ambitious, and has since proven a very costly decision when what was envisaged simply could not be economically produced. RAN capability will need to be 'high-end', but not necessarily the 'highest-end'. Also, the danger of expecting a single platform to perform a variety of missions in a high intensity operation is simply unrealistic. If a 'high-end' capability is required in combat operations, any other support or secondary role that may have been performed and depended upon in peacetime will no longer be a priority for this platform. The problem is the role may remain an important part of the overall capability, and the force may not have another platform available to fulfil 'low-end' but nonetheless important roles. An ASW helicopter may perform fleet support and transport duties during peacetime, but in the event of an operation where its primary ASW capability is needed, what platform will fill the former roles? Platforms must be procured in adequate numbers suitable to meet perceived contingencies, without a dependence on a 'multi-role' cure-all that will not be able to meet operational needs. This means a strong focus on support and not just combat capability roles. This point applies equally to ships as it does to aerospace platforms.

The quest for optimum capability may also come at the cost of regional security and the threat of counter-proliferation. With greater reach, endurance and precision, heightened awareness regionally of such threats by Australia, even if the ADF has no intention of mounting aggressive operations, may still be destabilising. With capability enhancement must come strategic transparency, regional engagement, alliance building, and a number of other confidence building measures to prevent alarmist reactions in our region.

Choice of platform or system in force structure decisions will vary, but the following capability trends would be the most beneficial for a flexible and capable RAN. These trends are predicated on the fact that the RAN's spectrum of operations will not change dramatically, but the capability to do them will. With the risk of block obsolescence, due a greater rate of change of technology than ever before, capability needs to be 'future proofed'. An open-architecture systems design will allow the continued development of the software that supports RAN capability whilst retaining most of the hardware to make it happen. Open-architecture will provide this, and also allow Australian science and industry to make an active contribution. As software and computing power advances, so too will the benefits to aerospace capability. A helicopter and UAV fleet that can upgrade to the latest combat or NCW system software block provides the capability benefits in interoperability and in maintaining the technology edge.

Physically too, capability obsolescence can be avoided through the employment of a Stanflex style of design, or weapons systems placed in vertical launch canisters. The adage 'fitted for but not with' is a sensible design philosophy, whereby capability integration can occur later when cost or technology allows it. Flexible hardware designs allow for system changes that may occur over a period of years into platforms that could be operational for decades. This significantly reduces costly maintenance and upgrade cycles, whilst also allowing the integration of advanced technologies such as lasers later when they may be more cost-effective and reliable. Such a design philosophy must be sought to expand beyond simply weapon system fit outs to cover sensor packages too. Inherent in UAV designs such as the *Global Hawk*, sensor bays allow package flexibility. Though ships have not traditionally shared this same flexibility to chop and change sensor fit-outs, there must at least be some facility to do so, with contemporary and future naval architecture design trends progressively reflecting these needs. Built in software and structural flexibility will allow future platforms to pursue evolutionary change within a ship's hull or airframe, and not a costly 'revolutionary' redesign.

The ADF will also need to invest heavily in NCW system operating architectures. Additional to the advantages of interoperability already discussed, NCW would be a force multiplier of a great magnitude for the ADF. The ability to gather and share information within a battlespace will be a significant future capability requirement. With a maritime concept of strategy, ships will be important information and support hubs, and aerospace surveillance capabilities will provide the vital intelligence and targeting information to protect the force beyond the range of organic ship sensors. The very fact an NCW capability is available to the RAN will mean that the only limit to the information it receives will be the size of the sensor constellation that gathers it, and how well it can disseminate and interpret the output. The important point to note here is that the NCW enabled force needs to encompass the maximum number of, if not all, the platforms in the system. This may be costly, and some platforms may not be as capable as others, but all platforms operating as part of the network need to draw upon and use the information generated to be efficient and relevant combat forces. The balance between the information that platforms can generate and the information that platforms can use needs to be carefully managed if trying to create a superior force. Whether part of a large US led coalition force or operating independently, ADF forces with networked systems will have greater access to the precious commodity of real time information in the maritime and littoral battlespace. At a minimum RAN assets need to be able to at least receive this data, and preferably transmit and receive it as well. With good information management and dissemination the RAN may have a greater chance of maximising its delivery of combat power precisely; with the right effect, and at the right time. Within a joint ADF force this can lead to significant benefits, with wide area sensor coverage reducing the need for mass, and increasing the result of effects.

To gather information within the future battlespace the RAN will need a wide array of sensors to cover geographically large areas. All evidence points to remote, unmanned vehicles to do this. With UAV technology advancing at such a rapid rate, and the cost benefits associated with economising their maintenance and personnel training, it is hard not to envisage the significant impact they will have on aerospace capability,[136] and the benefits they could provide to a sea power. Exploiting the benefits of endurance, persistence, low observability, flexibility and size, these platforms will be able to perform many duties that manned flight may not, cannot, or no longer needs to do. An important contribution to the ADF surveillance requirement, an RAN organic wide area surveillance capability through the employment of UAVs would complement RAAF AEW&C assets, a staple of the future aerospace combat environment.

Aerospace capability will continue to be an important capability for the RAN as an independent force, and as a sub-capability for some of the warfare requirements of its ships. It would be quite difficult to envisage any requirement not to have a flight deck or aviation capability on any future surface ship. Even for smaller patrol craft in the 2020 period, the utility of UAVs as an organic part of the platform's sensor package mandates at least some space being dedicated to their use. Equally so, the decision on the design of the RAN's future support, amphibious and air warfare platforms will be telling of the direction the service is advancing in respect to aerospace capability. One real capability enhancement would be the replacement of HMAS *Kanimbla* and HMAS *Manoora*[137] with a full flight deck amphibious command and control ship. Allowing for helicopter operations such platforms would also offer the ability to integrate a number of future ADF UAV designs. Australia could not afford an aircraft carrier of the CV or CVN sort, and within the current strategic outlook would have no need to do so. A less ambitious amphibious/aviation capable platform is a realistic capability, giving the ADF the advantage of a 'mobile airfield' in amphibious operations, and making a more significant political and military contribution to the region.[138] An amphibious helicopter carrier would enhance Australia's power projection through its amphibious and aviation capabilities, and allow for the enhancement of aerospace operations in the maritime and littoral environment.

To secure the bandwidth required for the many systems that will need information transfer, and to make use of many of the surveillance systems transitioning into space, the ADF cannot but continue to develop a robust space policy.[139] As space travel becomes more economical, space based communication facilities solely controlled by the Australian government would be a sensible acquisition, but by no means implies a massive constellation of sensors of our own. One or two regional geostationary[140] communications satellites would be advantageous. For the RAN, reliance upon satellites is a reality that will not diminish, and given current trends will only grow.

Serious consideration of an enhanced strike capability should also be studied. For the RAN as a force, and for the ADF as a whole, cruise missiles 'are a force multiplier of significant magnitude for a medium navy.'[141] Whether surface ship or submarine based, this capability would give a sizeable enhancement to the present RAAF F-111 strategic strike capability. The main advantage of the RAN's employment of this capability would be reach, especially if force projection is anticipated without the assurance of forward air basing of RAAF assets in an operation. In addition, the RAN can play an important role with the support, operation and control from ships of UCAVs armed with precision munitions as part of independent or coalition operations. Employment of aerospace capabilities from navy assets would facilitate enhanced combat power from the sea that utilises the advantages of both maritime and air forces. Such a capability balance could provide the appropriate mix of sea and aerospace power to significantly contribute to the EBO planned by a joint force commander. Even a limited 'high-end' strike capability could provide a niche force for large multinational effects based operations, and a strong deterrent in the defence of Australia mission.

Experimentation is an important process that can value add to the capability acquisition process. The ability to war-game and experiment with emergent capabilities, strategies and tactics gives decision makers a better understanding of the challenges facing the services, and how ADF capability may be best suited to deal with future threats. For the RAN, experimentation such as the Headmark program will continue to be an important means to model capability requirements and illustrate the complexities of the impact on tomorrow of the decisions that are made today.

The final area where RAN aerospace capability may be enhanced is through people and forward thinking. The 1990s Navy recruiting slogan ‘smart people, smart machines’ is somewhat apt to describe the future composition of RAN capability. Complex combat and battle management systems will continue to evolve, and with the added spectre of masses of real time intelligence and sensor information presented to warfighters there will need to be a defined shift in the thinking of Navy people. The transition from platform operators and geographic area warfighters into true battlespace and EBO managers will indeed be a paradigm shift for the ADF. RAN warfare specialists, like their other Service counterparts, will need to become significantly more aware of the overall battlespace, how to manage it and, of equal importance, how to lead in it.[142] Training needs to reflect this now to ensure the necessary joint mindset is developed and fostered within the RAN warfare community. With AEW&C and Air Warfare Destroyers to be working concurrently within a networked sensor constellation, and directing the JSF and fleet based weapons, the battlespace and systems knowledge to integrate such a capability effectively will need to move further from present single-service mindsets. Aerospace platforms in the maritime environment must not be considered Air Force or Fleet Air Arm assets, but air power assets, and must be treated jointly and shared as required within the joint battlespace.[143] The ADF is progressing with a joint outlook, and the RAN must continue to promote and foster a joint mindset in addition to employing advanced joint systems.

Future Aerospace Capability Implications for the RAN Sea Control Mission

RAN Doctrine clearly establishes the importance of sea control in the maritime battlespace.[144] The freedom of moving and operating a naval force in the maritime environment at all times requires some level of sea control to achieve this mission, and is considered an ‘essential element’ for ADF forces, whether acting unilaterally or as part of a coalition.[145] The important point to note with sea control is that it is transient and localised in nature. Unlike command of the sea, which engenders a permanence that only a prohibitively large force could achieve, sea control only implies ‘use of a limited area for a limited time.’[146] Accordingly, as a medium power, the RAN may achieve varying levels of sea control, whereas command of the sea is out of the question even for the remaining global superpower, the USA. Most importantly, sea control is required across the whole spectrum of conflict.[147] No matter what the operation some level of sea control is required, and therefore it may be considered the core mission that the RAN is required to satisfy for the ADF to dominate the battlespace.

To this end, the need for a robust maritime force is as important as it ever has been. The future fleet will need to counter the plethora of proliferating capabilities outlined above. This fleet will need a complex force mix and array of capabilities of its own to generate a balanced force. The future advances in aerospace capability outlined above offer a number of advantages to the RAN's ability to satisfy the sea control mission.

What then of the impact of these capabilities on the RAN's ability to achieve sea control? The main areas where these advances are likely to affect the sea control mission are in the broad areas of speed, reach, bandwidth and flexibility.

Advances in aerospace capability will have a continued impact on aspects of time in which maritime operations take place. Advanced supersonic missiles will strike targets faster, present a shorter warning time, and will require faster methods of detection and neutralisation. Airborne sensor constellations may be able to gather more information within the battlespace and provide information in real time. RAN assets involved in sea control will face airborne threats that will materialise with little or no warning (of particular concern in the littoral), and may themselves strike with great speed. Time will therefore be a commodity in the future maritime battlespace, where capabilities need to match the increased speed of the battlespace—faster weapons, faster reactions, and faster information flow. This does not affect the transient nature of the geographic area defined by sea control, nor does it change the fact that sea control is time limited. It does clearly show how the speed of information and threats presented by these advances compresses the challenges faced by the RAN task force in achieving sea control within a given timeframe relative to the threats faced today.

The gathering of information within the battlespace links with the idea of reach. With aerospace sensor constellations as part of the naval task force, dedicated airborne surveillance will allow access to information over a far wider area than that offered by organic surface units. AEW&C has been present at sea for a few decades in fixed and rotary wing forms within carrier groups, but the ability of the medium navy to provide such important surveillance of the battlespace without these assets has been limited to organic sensors. As the technologies described above mature, satellites, manned and unmanned aerial vehicles, ship and submarine organic sensors, and UUVs will all contribute more cohesively to building the battlespace picture, and will become more accessible to many navies. Battlespace management has always occurred to some extent, but the predicted outcomes of the networked force's control of the battlespace are an order of magnitude greater than anything achieved previously. With a networked force utilising this array of sensors, particularly aerospace platforms, the information gathered will produce a larger volume of intelligence on a far greater geographic area for the RAN than is presently possible. UAVs should provide the medium navy with a tool to add the reach to a networked force that would once have been the preserve of navies with a carrier capability. The importance of the information gathered over a wide area to a CEC equipped force is that it will allow the force to detect, identify and neutralise threats more comprehensively, and thus establish a more thorough and effective level of sea control where required. Where sea control is concerned the RAN task group will be able to see further, interpret more information, and act on it faster.

A significant feature of achieving a superior level of battlespace awareness will be the breadth and security of the electromagnetic spectrum upon which those controlling the sea will rely. Bandwidth in a large networked force is an issue, where the larger force will need to transfer masses of information and control data streams before any interpretation of the intelligence gathered could even begin. To control the sea the networked force will be reliant on superior situational awareness, which it gathers through an extensive sensor constellation. In a CEC capable force that relies upon the network to detect and engage threats rapidly the lines of communication need to be seamless against time critical threats. Bandwidth security will be the 'Achilles heel' of such a force, where corrupted data streams, overloaded networks, stringent emission control or enemy jamming all threaten the quality of the information flow, and thus the effectiveness of the task force. For the future networked maritime force, control of the sea will require control of the electromagnetic spectrum to operate effectively.

The final impact of aerospace capability on a future RAN force will be the flexibility to the commander that such assets could provide to the sea control mission. UAVs can remain on task for longer than manned platforms, and can perform reconnaissance missions such as battle damage assessment without risking the life of aircrew and their more expensive platforms. UCAVs would have the ability to deliver munitions against a variety of threats at a greater standoff range from the task group. These are some simple examples of what these aerospace capabilities can bring to the force. Some have already been proven in operations by other countries, and are proliferating capabilities today, while some capabilities such as UCAVs are still in development. The importance of these capabilities for sea control is that they offer enhanced options to the force commander, as aerospace platforms do today, and as they have done in the past. The importance of these developing capabilities for the future is that they move beyond manned rotary wing platforms, they enhance the reach and situational awareness of the force, and they will increasingly fall within the economic reach of a medium navy like the RAN. Enhanced aerospace capabilities will provide the future fleet a wider array of options to deal with future contingencies in the maritime battlespace when aiming to attain control of the sea. 'The attainment of sea control is the necessary maritime component of battlespace dominance.[148] Improved organic RAN aerospace capabilities will offer the flexibility to force commanders to help achieve this in an increasingly complex and dangerous maritime battlespace.

Conclusion

The future ability of the ADF to provide flexible capability options to government to protect national interests against a myriad of foreseeable and unknown security challenges will be limited, especially for the RAN as a medium power. If the ADF is to project force off Australia's shores in support of the national interest, the RAN will provide vital capabilities. To achieve this, sea control is a prerequisite of such operations, and thus the RAN needs the right tools to properly protect any force that deploys in the maritime environment. The introduction of many of the predicted capabilities brought about by the RMA to provide effects based military results in the littoral and other environments will need the extensive exploitation of aerospace platforms. Aerospace power is a key element of capability that the RAN must not neglect, and one where it can derive immense military advantage if carefully fostered, and would provide a significant contribution to the sea control mission. The task of ensuring the RAN gets the 'best bang for its buck' is certainly challenging, but not insurmountable.

To create a balanced and effective aerospace capability the RAN will have to examine closely the present aerospace technologies, and those that are deemed more exotic. These will be the options to consider today that will be present in the order of battle tomorrow. The future RAN force needs to be a flexible, upgradeable, and networked joint force, whose warfighters lead in the management of the combined open ocean and littoral battlespace. For the RAN to maximise its air power over the period 2020–2030 the force needs to be flexible, robust and prepared, and it will take careful planning over the next few years to make the decisive difference. In utilising the potential of aerospace power, the RAN would only become a more formidable sea power in the process.

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[8] Fourth Generation Warfare includes any form of conflict where unconventional military opponents (not necessarily affiliated to a state or government) employ asymmetric methods to counter conventional western military power. E.g. Al-Qa'ida.

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[11] *Fundamentals of Australian Aerospace Power*, Aerospace Power Centre, Canberra, 2003, pp. 123–140.

[12] *Australian Maritime Doctrine: RAN Doctrine 1*. Department of Defence, Canberra, 2000, pp. 48–52.

[13] Ibid, p. 52.

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19 General Cosgrove in the foreword to *Future Warfighting Concept*, ADDP-D.3, Department of Defence, Canberra, 2002.

20 *Force 2020*, op cit, pp. 17–22.

21 *Future Warfighting Concept*, op cit. p. 23.

22 This paper only refers to the unclassified public version of 'Plan Blue,' as it deals directly with the time frame of this study. 'Plan Blue' is officially known as *Australia's Navy for the 21st Century: 2001–2030*, Department of Defence, Canberra, 2001.

23 Also described as Network Centric Warfare (NCW), or Network Enabled Warfare.

24 *Force 2020*, op cit, p. 19.

25 *Future Warfighting Concept*, ADDP-D.3, Department of Defence, Canberra, 2002. p. 12.

26 Ibid, p. 12.

27 Stephens, A. (2000), op cit, p. 172.

28 *Australia's Navy for the 21st Century: 2001-2030*, Department of Defence, Canberra, 2001, p. 12.

29 *Australian Maritime Doctrine*, op cit, p. 13.

30 Bostock, I. (2002). "Australian Army embarks on a far-reaching strategy," in *Jane's Defence Weekly*, October 30, 2002, p. 1.

31 "The RAN mission is to:

- be able to fight and win in the maritime environment as an element of a joint or combined force.
- assist in maintaining Australia's sovereignty.
- contribute to the security of our region."

Australian Maritime Doctrine, op cit, p. 5.

32 *Fundamentals of Australian Aerospace Power*, op cit, p. 137.

33 *Force 2020*, op cit, p. 11.

34 Ibid, p. 11.

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[35] Bethel, S., Chew, N., Near, J., Nostrand, P., & Whitehead, Y. (1996). *2025- Information Operations: A New Warfighting Capability*, Air University Student Research Paper, 1996. p. 2.

[36] *Australia in the World*, op cit, p. 20.

[37] Examples of innovative Australian industry developments include:

- CEA Technologies unique phased array search and target indicating radar systems (the CFAR concept).
- The Aerosonde UAV using the Iridium commercial satellite network for beyond line of sight flight control of the aircraft, anywhere in the world.
- The Metal Storm company whose range of electrically fired projectile weapons are drawing extensive international interest.

[38] *Australia's National Security*, op cit, p. 9.

[39] This is known as 'Moore's Law', where the doubling of transistor power every couple of years explains the exponential processing growth. *Silicon: Moore's Law*, from www.intel.com, downloaded 13 May 2003.

[40] Colonel John Boyd's 'OODA Loop' was developed as a decision making process that allowed an individual to make rapid decisions and outsmart ones opponent. As a fighter pilot in the Korean War his experience helped him to develop this cycle, which he later expanded in scope beyond air combat. This theory is now widely used for many other decision-making applications. *Fundamentals of Aerospace Power*, op cit, p. 56.

[41] Vice-Admiral Cebrowski quoted in Scott, W. & Hughes, D. "Nascent Net-Centric War Gains Pentagon Toehold", in *Aviation Week and Space Technology*, p. 2. Vice-Admiral Cebrowski (past commandant of the Naval War College and now retired) was, and remains, a strong advocate that NCW will form the foundation of future warfighting operations.

[42] Kruzins, E. & Scholz, J. (2001). "Australian Perspectives on Network Centric Warfare: Pragmatic Approaches with Limited Resources", in *Australian Defence Force Journal*, no. 150, September/October, 2001. p. 19.

[43] Ibid, p. 19.

[44] Scott, W. & Hughes, D. op cit, p. 2

[45] Open architecture design allows software to be continually upgraded and improved to enhance performance, without the need to acquire entirely new software.

[46] Though the US is aggressively developing CEC, others such as France are aiming for a similar but not necessarily advanced capability. European navies have identified that although they may not be able to afford the systems themselves, they do wish to have the ability to 'plug-in' and share sensor information in the future. Scott, R., and Lok, J., "Euronaval – France seeks Euro answer to USN network capability", in *Jane's Defence Weekly*, 30 October 2002, p. 1.

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[47] Scott, R., "Raytheon, Lockheed Martin team for CEC Block 2", in *Jane's Navy International*, posted 25 February 2003. p. 1.

[48] Such an example is Link 16, a jam proof and encrypted digital data transmission tool that does not rely on fixed nodes to support the system.

[49] Fulghum, D., "It Takes A Network To Beat A Network", in *Aviation Week and Space Technology*, posted 11 November 2002, p. 4.

[50] Ibid, p. 1.

[51] The GSTF as part of the US Air Expeditionary Force is designed to utilise B-2 bombers (protected by the F-22 fighter) to perform the SEAD mission to allow allied aerospace capabilities free access to enemy airspace. See Jumper, J., "Global Strike Task Force: A Transforming Concept, Forged by Experience", in *Aerospace Power Journal*, Spring, 2001.

[52] Goure, D. "Location, location, location…" in *Jane's Defence Weekly*, 27 February 2002, p. 25.

[53] Present datalink processors simply cannot cope with the capacity, update rate and message error rates, plus the added challenges of countering jamming and poor environmental conditions affecting signal propagation. "CEC Design Principles", in *Jane's Navy International*, posted 13 December 2002, p. 1.

[54] Morris, J., "Lockheed Martin Extends Navy CEC Network Through Milstar Satellite", in *Aviation Week's Aerospace Daily*, 29 January 2003, p. 1.

[55] Braybrook, R., "Hale High in the Sky", in *Armada International*, June/July, 3/2003, p. 56.

[56] Scott, W., "UAVs/UCAVs Finally Join Air Combat Teams", in *Aviation Week and Aerospace Technology*, posted 8 July 2002, p. 2.

[57] Glaskin, M., "Torque it up: Expect a spate of new UFO sightings if this spy plane takes to the air", in *New Scientist*, 2 February 2002, p. 20.

[58] Ibid, p. 1.

[59] Hoyle, C., and Koch, A., "Yemen drone strike: just the start?" in *Jane's Defence Weekly*, 13 November 2002, p. 1.

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[61] General Hal Hornburg, Commander Air Combat Command, quoted in Sirak, M., and Cook, N., "US Air Force mulls role of unmanned platforms", in *Jane's Defence Weekly*, 30 October 2002, p. 1.

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[64] "Skunk Works show UAV stripes", in *International Defence Review*, 1 October 2002, p. 2.

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[66] "Ultra-lightweight air vehicles", in *International Defense Review*, 1 October 2002, p. 1.

[67] "Weapon Locates Target on Its Own", in *Defense News*, 31 March 2003, p. 18.

[68] Cohen, W., "Cohen on Airpower", in *Airforce: Journal of the Air Force Association*, January 2000, p. 2.

[69] Hoyle, C., "UK commits to STOVL future", in *Jane's Defence Weekly*, 9 October 2002, p. 1.

[70] USMC Commandant General James Jones quoted in Ibid, p. 1.

[71] P-3C Orion's fired SLAM land attack missiles against Yugoslavian targets during 1999's Operation 'Allied Force.' Annati, M., "MPA Revisited: A review of ongoing Procurement and Upgrade programmes", in *Military Technology*, December 2002, p. 22.

[72] Ibid, p. 23.

[73] Ibid, p. 28.

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[75] Ibid, p. 6.

[76] AWACS and Joint STARS aircraft have specific sensors to provide command and control support for the air and surface battles respectively.

[77] Perryman, G., "Shortening the decision cycle", in *Intelligence, Surveillance and Reconnaissance Journal*, March/April 2003, p. 33.

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[79] Tethered Aerostat Systems are small airships that carry a sensor payload and are operated alone or networked together to form a wide area surveillance system. *Tethered Aerostat Systems*, from www.lockheedmartin.com, downloaded 13 May 2003.

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[109] Trimble, S., "Air Force Opens Testing On 500-Pound JDAMs For B-2", in *Aerospace Daily*, 25 Mar 2003, p. 1.

[110] Simonsen, E., and Algarotti, B., *Boeing Awarded Small Diameter Bomb Contract*, downloaded 1 May 2003 from http://www.boeing.com/news/releases/2001/q4/nr_011003b.html

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[112] Roche, J., "Word for Word", in *Defense News*, 28 April 2003, p. 20.

[113] "Meeting the Challenge of Elusive Ground Targets", in a *RAND Research Brief*, RAND, Santa Monica, 2001, p. 5.

[114] Nielsen, P., "Interview: Maj. Gen. Paul Nielsen- Commander U.S. Air Force Research Laboratory", in *Defense News*, 3 March 2003, p. 30.

[115] The effects of such weapons on ships would also be devastating, where the ability to detect, identify and destroy a hypersonic target before it hit the ship would be extremely difficult. Even if you did destroy the weapon, supersonic debris striking the ship would still cause extensive and serious damage. Hewish, M., "Taking the hype out of hypersonics", in *Jane's Defense Review*, 1 August 2002, pp. 1–2.

[116] New Naval gun variants under development include electro-magnetic, light gas, ram accelerator, electro-thermal, liquid propellant and advanced solid state propellant guns. "US studies exotic weapon solutions for ship defence", in *Jane's Navy International*, 1 March 2002, p. 2.

[117] Fulghum, D., "USAF Acknowledges Beam Weapon Readiness", in *Aviation Week and Space Technology*, posted 4 October 2002, p. 2.

[118] "Taking the hype out of hypersonics", Op cit, pp. 1–2.

[119] Sirak, M., "USAF may study laser in ground-attack role", in *Jane's Defence Weekly*, 13 November 2002, pp. 1–3.

[120] Space based laser, originally slated for trials around 2012, has since been deemed high risk for development with present technology. Accordingly funding and research has been reduced and redirected to the ABL. Tirpak, J., "Attack at the Speed of Light", in the *Journal of the Air Force Association*, Vol. 85, No. 12, December 2002, pp. 1–5.

[121] "Metal Storm technologies adopted for multiple programs", in *International Defense Review*, 1 February 2003, pp. 1–3.

[122] Koch, A., "USA works on network of 'sleeping' weapons", in *Jane's Defence Weekly*, 13 November 2003, pp. 1–2.

[123] "Shape-memory alloys for micro-actuation", in *International Defense Review*, 1 December 2002, p. 1.

[124] *Future Warfighting Concept*, p. 28.

[125] *Australian Maritime Doctrine*, p. 94.

[126] *Australia's Navy for the 21st Century: 2001-2030*, p. 16.

[127] Derived from ADFP 4. *Military Capability*, from intranet.defence.gov.au, downloaded 12 May 2003.

[128] Ibid, p. 8.

[129] Smith, G., "Stating the problem: facing the challenge", in Wilson, D. (ed.), *Maritime War in the 21st Century*, Papers in Australian Maritime Affairs, No. 8, 2001, p. 5.

[130] *Australia's Navy for the 21st Century*, p. 8.

[131] Smith, G., Op cit, p. 7.

[132] Friedman, N., *New Technology and Medium Navies*, Working Paper No. 1, Royal Australian Navy Sea Power Centre, Canberra, 1999. p. 2.

[133] Blackburn, J., "Knowledge in the Australian Theatre- Airpower: Our People, Their Knowledge", in Brent, K. (ed.), *Air Power Conference 2000: Air Power and Joint Forces*, Aerospace Centre, Canberra, 2000, p. 163.

[134] Ibid, p. 163.

[135] Friedman, N., *New Technology and Medium Navies*, p. 4.

[136] A number of Australian studies of UAVs have outlined their future utility and importance as a capability for the RAN, and the wider ADF. References include:

Ashworth, P., *Unmanned Aerial Vehicles and the Future Navy*, Working Paper No. 6, Royal Australian Navy Sea Power Centre, Canberra, 2001.

Lax, M., and Sutherland, B., *An Extended Role for Unmanned Vehicles in the Royal Australian Air Force*, Air Power Studies Centre, Canberra, 1996.

Ware, M., "UAVs in an Australian Maritime Environment", in *Birds Away: The Surface Combatant Force Element Group*, Issue 4, September 2002, pp. 4–8.

Yeaman, M., *Virtual Air Power: A Case for Complementing ADF Air Operations with Uninhabited Aerial Vehicles*, Air Power Studies Centre, Canberra, 1998.

[137] These are helicopter capable amphibious transports. Originally in commission with the USN as *Newport* Class tank landing ships they were extensively modernized and refitted after 1995 to remove the tank landing capability, but redesigned to include an improved flight deck, expanded

hangar space, improved C2 facilities, a medical facility, and the capability to deploy landing craft. See *Navy Today*, Department of Defence, Canberra, 2003.

138 Grove, E., "Medium navies and organic air", in Wilson, D. (ed.), *Maritime War in the 21st Century*, Papers in Australian Maritime Affairs, No. 8, 2001, p. 99.

139 Nicholson, P., "Aerospace Power- The Military Use of Space", in Brent, K. (ed.), *Air Power Conference 2000: Air Power and Joint Forces*, Aerospace Centre, Canberra, 2000, p. 103.

140 A geostationary satellite remains over the same point of the earth, allowing for constant payload coverage of a designated geographic area.

141 Willett, L., Op cit, p. 103.

142 Stephens, A., "The Future of Air Power in the Maritime Environment", p. 25.

143 Ibid, p. 17.

144 Sea control is defined by RAN Doctrine as "That condition which exists when one has freedom of action to use an area of sea for one's own purposes for a period of time and, if required, deny its use to an adversary. The state includes the air space above, the water mass and seabed below as well as the electro-magnetic spectrum. To an increasing degree, it also includes consideration of space based assets." *Australian Maritime Doctrine*, p. 162.

145 Ibid, p. 42.

146 Baer, G.W., *One Hundred Years of Sea Power: The U.S. Navy 1890-1990*, Stanford University Press, Stanford, 1996. p. 404.

147 *Australian Maritime Doctrine*, p. 40.

148 Ibid, p. 43.