Next Generation Autonomous Systems

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By Dr. Robbin F. Laird, Research Fellow, The Williams Foundation

In this report, the key themes and presentations at the April 8, 2021, Williams Foundation seminar on Next Generation Autonomous Systems are highlighted. A number of interviews with participants are included as well as insights from earlier interviews from pre-COVID visits to Australia.

In addition, selected articles are included in an appendix which address the question of shaping a way ahead with regard to manned-unmanned teaming and the coming of autonomous systems.

The original seminar was scheduled for March 2020 but was postponed due to COVID-19.

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THE SEMINAR

On April 8, 2021, the Williams Foundation held its latest seminar, one that was originally scheduled for March 2020.

This is how the seminar was prologued in the run up to the seminar itself.

Since 2013 the Sir Richard Williams Foundation seminars have focused on building an integrated fifth generation force. Recent seminars have evolved from the acquisition of new platforms to the process of shaping and better understanding the environment in which the integrated force will prepare and operate. Moreover, they have highlighted the challenges of acting independently at an accelerated tempo and in sustained, high intensity, complex Joint operations.

While COVID-19 prevented the Foundation from hosting any seminars in 2020 the narrative remains. The 2021 seminars will therefore continue to develop the ideas associated with an increasingly sophisticated approach to Joint warfighting and power projection as we face increasing pressure to maintain influence and a capability edge in the region.

Following on from the October 2019 seminar titled 'The Requirements of Fifth Generation Manoeuvre', the 2021 series of seminars and lunches will examine:

- ***the emerging requirements associated with trusted autonomous systems, and***
- ***the growing importance of Space as an operating domain.***

In doing so, they will each address how the Australian Defence Force must equip, organise, connect, and prepare for multi-domain operations. As ever, the Sir Richard Williams Foundation has identified pre-eminent speakers from across the Australian and international defence communities, as well as invited industry representatives to reflect the integral role they will play in the national framework of future operational capability.

April 2021 Seminar Outline – Next Generation Autonomous Systems

Building upon the existing foundations of Australian Defence Force capability, the aim of the April seminar is to explore the force multiplying capability and increasingly complex requirements associated with unmanned systems. From its origins at the platform level, the opportunities and potential of increased autonomy across the enterprise are now expected to fundamentally transform Joint and Coalition operations. Defence industry can and will play a major part in the transformation with opportunities extending beyond platforms to the payloads and enabling systems which underpin the necessary risk management and assurance frameworks demanded by Defence. The importance of industry is reflected in the design of the seminar program and the speakers identified.

The concept of the Unmanned Air System (UAS), or Unmanned Aerial Vehicles (UAV), is nothing new nor is their use in missions which traditionally challenge human performance, fragility, and endurance. Often described as the dull, dirty, and dangerous missions, unmanned

systems have now provided the commander with a far broader range of options for the application of force against even the most challenging target sets. However, ongoing operational experience confirms unmanned systems on their own are not the panacea and trusted autonomy in manned and unmanned teaming arrangements in each environmental domain is emerging as the game changer.

The narrative is now forming across defence which has progressed the argument for greater numbers of unmanned systems in a far more mature and balanced way than hitherto. The manned-unmanned narrative is now sensibly shifting towards 'and', rather than 'or'. Manned and unmanned teaming leverages the strengths and mitigates the weakness of each platform and concentrates the mind on the important operational aspects, such as imaginative new roles, and the challenges of integration to generate the desired overwhelming firepower.

This capability will require a complex web of advanced data links and communication systems to make it operate as a combat system. Designing and building the 'kill web' so that it can enable the delivery of manned-unmanned firepower across domains will be a huge challenge not least due to the laws of physics. However, the ability to train, test, evaluate and validate tactics and procedures will add a whole new level of complexity to generate the 'trusted autonomy' required for warfighting.

The aim of the April 2021 seminar, therefore, will be to promote discussion about the near and far future implications of autonomous systems, and to build an understanding of the potential and the issues which must be considered in the context of the next Defence White Paper and Force Structure Review. It will investigate potential roles for autonomous systems set within the context of each environmental domain, providing Service Chiefs with an opportunity to present their personal perspective on the effect it will have on their Service.

The seminar will also explore the operational aspects of autonomous systems, including command and control and the legal and social implications that affect their employment. And finally the seminar will examine the current research agenda and allow industry an opportunity to provide their perspective on recent developments in unmanned air, land, surface and sub-surface combatants. Each of which are opening new ways of warfighting and creating opportunities to reconceptualise Joint operations and move away from the platform-on-platform engagements which have traditionally characterised the battlespace.

The speakers and the agenda for the seminar can be seen in the appendix.

PERSPECTIVES ON THE INTRODUCTION OF AUTONOMOUS SYSTEMS INTO COMBAT

The seminar began with two presentations which focused on the nature of the challenges of introducing autonomous systems into the combat force.

The first presentation was by Group Captain Jo Brick of the Australian Defence College. Brick frequently provides the initial presentation for a Williams Foundation seminar and provides very helpful orientations to the issues to be discussed at that particular seminar. It was no different with regard to the challenging topic of understanding the nature and the way ahead for next generation autonomous systems.

She highlighted a number of fictional examples of how the machine-man relationship has been envisaged in the future. But she honed on a key aspect of the challenge: how will data flow in the combat force and how will that data be used to make lethal decisions?

She posed a number of key questions facing the way ahead for the introduction and proliferation of autonomous systems into the combat force.

Do we trust the systems that we have created?

Are we expecting them to be perfect, or to accept that they are flawed just like us?

Do we understand autonomous systems enough to information the creation of an effective system of accountability?

How would autonomous and intelligent systems make decisions, free from human intervention?

Would they reflect the best of humanity or something less inspiring?

Does the conduct of war by autonomous and intelligent systems dilute the sanctity of war as a societal function?

Who or what is permitted to fight wars and to take life on behalf of the state?

What does the use of AI and autonomous systems in warfare mean for the profession of arms?

One could add to her questions another one which was discussed directly or indirectly throughout the seminar: What will be the impact of the introduction and proliferation of autonomous systems on the art of warfare?

The second presentation, which followed that of Group Captain Brick, was by Professor Rob McLaughlin from the Australian National Centre for Oceans Resources and Security. In his presentation, McLaughlin dealt with the broader ethical and legal issues which autonomous systems raise and which need to be resolved in shaping a way ahead for their broader use in the militaries of liberal democratic states.

One should note that another key question is how authoritarian states use and will use them which is not restricted by the ethical concerns of liberal democratic societies. There is always the reactive enemy who will shape their tactics and strategies in ways taking into account how the liberal democratic militaries self-limit with regard to systems, like autonomous ones.

McLaughlin started with the most basic question: What is an autonomous weapon system? He turned to a definition provided by the International Red Cross which defines AWS as follows:

"Any weapon system with autonomy in its critical functions. That is, a weapon system that can select and attack targets without hum intervention. After initial activation by a human operator, the weapons system – through its sensors, software (programming/alogrithms) and connected weapon(s) – takes on the targeting function that would normally be controlled by humans."

He then added this consideration as well from the International Red Cross as well: "The key distinction, in our view, from non-autonomous weapons is that the machine self-initiates an attack."

This raises in turn the key consideration of when is the AWS (in legal terms) an independent unit (like a warplane or warship) rather than simply a sensor/weapon?

This in turn raises a further consideration: Can a maritime autonomous weapons system be a warship in terms of international law? According to the Law of the Sea: "For the purposes of this Convention, warship means a ship belonging to the armed forces of a state bearing the external marks distinguishing such ships of its nationality, under the command of an officer duly commissioned by the government of the state and whose name appears in the appropriate service list or its equivalent and manned by a crew which is under regular armed forces discipline."

Such a definition quickly raises issues for autonomous maritime platforms. Are they marked with the nation's identification? Are they introduced such as the Germans in World War II did with merchant "warships" without such markings? What does under command mean specifically as autonomous maritime platforms operate? Is there a mother ship which controls them which is crewed by humans? And if uncrewed then what about the manning issue?

He argued that we are not yet at a threshold where these are practical questions impeding development. But we "will meet a frontier at some point – probably with AI and advanced machine learning."
In short, with autonomous systems on the horizon, a number of questions about how they will impact on the force, and how concepts of operations using these capabilities will face ethical and legal challenges as well.

HOW TO THINK ABOUT NEXT GENERATION AUTONOMOUS SYSTEMS IN THE EVOLVING DEFENSE LANDSCAPE

A key consideration facing autonomous systems is how will they enter the force, how will they be part of force transformation and how best to understand how the manned-unmanned force mix might evolve?

The presentation by Marcus Hellyer, a well-known and regarded defence analyst at the Australian Strategic Policy Institute, provided a particularly insightful look at how one might consider the way ahead for the entry of NGAS into the force as well as how the overall force might be calibrated for the future fight.

I had a chance to discuss his presentation and his thoughts with him in a recent phone discussion and interview. I started the discussion by summarizing how I read his presentation and approach. Hellyer looked at the broader topography of the forces and asked the question, where might autonomous systems fit into where we need to drive our force structure? The force is moving in the direction of being more disaggregated and autonomous systems will be useful in that process.

How do we manage disaggregation and what might be the role of NGAS in that process as well as providing more cost-effective options as well?

Question: Is that a fair way to summarize your argument?

Hellyer: "It is. I like you get a little frustrated when we bog down in endless debates about hypothetical futures for AI or the legal and moral and ethical aspects of autonomy. I'm not really after autonomy for its own sake. Autonomy is a tool, not an end in itself.

"Like you, I'm very interested in moving towards distributed concepts, whether you want to call them the distributed kill web or mosaic warfare or whatever the term is that you want to use, I think that's where we need to be going.

"In part, it is also about cost effectiveness as well. To paraphrase recent US Navy CNO comments: Can we continue to build $3 billion ships to carry 32 VLS cells? We need to start harnessing the disruptive potential of disaggregated systems.

"To get out of that kind of cost death spiral, we need to disaggregate capability. The bottom line is simple things are cheaper. Simple things are faster to build, and so you can build a lot more of them. To do that, you have to disaggregate capabilities off three-billion-dollar ships into smaller entities. But to make those entities relevant, you then need to link them together so they can talk with each other and work together.

"But to me, you need to disaggregate simply so you can get more sensors and more weapons into the air or into the water, and to shape a more resilient system.

"In my presentation to the Williams Foundation I spent quite a bit of time looking at a kind of analogous transition. I did that to make a couple of points. The first one is that really disruptive transitions can sneak up on you quite quickly. If you're not prepared for them, you will be taken by surprise. And we have a really good example of a complex system of systems using disaggregated components that is evolving in front of us. The example I used was Australia's electricity sector. Our electricity sector has dramatically transformed just in a very small period of time.

"I highlighted a screen grab from an app that shows at any point in time where Australia's electricity supply is coming from. A couple of weeks ago, we hit a point where over half of our electricity supply was coming from renewable sources. So that transition to renewables has actually progressed quite a long way. We've reached a tipping point. I know tipping point is a cliché but we're there, not because renewables now provide all of our electricity or even most of it. That 50% point was obviously one moment in time when the wind was blowing, and the sun was shining. It's not hitting close to 50% all the time. But last year, about 28% of our electricity came from renewables.

"We've reached a tipping point in the sense that the commercial sectors does not want to invest its own money in traditional forms of generation; no business wants to build a coal-fired power plant. No business really wants to build a natural gas power plant. Only the government is considering whether it will pay to do that. We've reached that kind of tipping point where business thinks that it's not economically viable to keep investing in fossil fuel powered generation. A transition has occurred; it's just our thinking hasn't really caught up with it in some ways.

"And this analogy also speaks to the distributed issue with regards to defense. The new electricity grid is not based on a small number of very large generators. It's based on a large number of generators that range from small to larger. Australia has one of the highest take ups of rooftop solar panels in the world. You have private houses around Australia who are now feeding electricity into our electricity grid. So we range from individual households up to very large generators. We still do have some coal-fired power plants, but out in the countryside, we now have very, very large commercial-scale solar and, as in America, very large wind farms.

"But that's a different kind of grid. You've got lots of contributors switching on and off, feeding in at different times, turning on in response to the market, turning off when the wind doesn't blow, or the sun doesn't shine. It requires a much more flexible, agile kind of grid and requires some of the kinds of autonomous brainpower that a military distributed kill web would require.

"I talked about that because I think it's a really nice example of a transition that's occurring in front of our eyes, but it's also a transition that I think has some really nice relevant analogies for the military in terms of a more distributed grid suggesting what force distribution can provide as well."

Question: What you are describing is the emergence of a mixed power system, where clearly fossil fuel remains crucial in many ways and funding to generate such capabilities is crucial to Australia's ability to have security of supply as well. It's a different mix, but the mix is being driven by introducing new capabilities and new approaches. To your point, it also allows you to think about a more viable grid in terms of not being so dependent on a small number of larger generating plants and transmission belts.

In a way this is an analogy to a distributed military kill web where you are shaping multiple ways to generate the combat effect one wants rather than relying on single point of failure large systems. Is that a fair characterization of your argument?

Hellyer: "It is. I think one useful kind of observation from the electricity sector is that rather than focusing on the capability of the individual generator we need to lot at the resilience of the entire system. Renewables will always look poor compared to a really big traditional generator, whether it's gas or coal or nuclear because a single facility generates less power. But we need to look at their contribution to the resilience of the entire system. In that regard, a renewable grid or a combination grid is much more resilient in many ways.

"If you look at in the electricity sector, don't look at the new technology as a like for like replacement for the old technology. We were talking earlier about the Osprey. If you look at the Osprey as simply a fast helicopter, you are kind of missing the point.

"So in the electricity grid, large scale batteries are not really there to replace coal-fired power plants. If you look at them in that regard, they'll look like very poor replacements. What batteries do is they can stabilize the grid because they can switch it on and off instantaneously in response to demand. And because they can switch on and off so quickly, they completely outperform traditional generators in response to the spot market in the electricity sector.

"They actually have a different kind of capability and one that it really out competes the traditional generators. They are smaller but to use a military term, they are much more agile. They play a different role, but a complimentary one with the larger, traditional power generators. The challenge when we're looking at new technologies is not to look at them as like for like replacements of what we have now, but actually to see what they do differently–that seems to be a particular challenge for militaries where the continual, daily competition of the marketplace isn't at work.

"Another useful analogy between the electricity sector and the military is the issue of sunk cost and how to avoid 'stranded assets'. Whether we're talking about an LHD or a coal-fired power plant, if it's in service, we've put so much money into it that we're going to keep using it so we'll need to find ways to adapt it and find a way to use it usefully in that web or mix of technologies.

"If we use a private sector analogy for the military, what we need to focus upon is shaping a balanced portfolio. NGAS will enter the force to provide a balanced portfolio. And one of the potential advantages with NGAS is an ability to put them into play much more rapidly than you can with large platforms, capabilities which enhance the force. They offer you the ability to keep your big, traditional investments relevant.

"The big question, and one we probably can't answer yet, is how much money do you keep committing to build those exquisitely capable yet extremely expensive traditional platforms like frigates and submarines? When do you turn that off? And how much do you put into the newer autonomous technologies, which to some degree are riskier because we don't know exactly what's going to become of them. We don't know exactly how to use them. We don't know exactly how to integrate them together and how all the command-and-control networks are going to work.

"But as another speaker at the Williams Foundation conference said, we need to have 'a bias toward action'. That is, we can't solve all the issues around autonomy in the abstract. We need to experiment and invest and solve as we go. Again, the electricity sector offers a nice analogy. Initially we started out with a few people putting some solar panels on their roof. That only grew slowly at first and very few people thought then that they could drive our power grid, yet here we are today with nobody wanting to put new money into the old technology."

SHAPING THE WAY AHEAD FOR ROBOTIC AND AUTONOMOUS SYSTEMS AND ADF FORCE DEVELOPMENT

CDRE Michael Turner, Director General of Force Exploration at the Australian Department of Defence, provided an overview on how to conceptualize the way ahead for the ADF and its force development as it adapts to remote autonomous systems.

As Director General Force Exploration, CDR Turner reports to Vice Chief of the Defence Force (VCDF) Vice Admiral David Johnston, who is responsible for joint force integration, interoperability, designing the future force, preparedness and military strategy in his role as the Joint Force Authority. The Joint Force Authority is responsible for ensuring the current and future joint force meets the capability requirements directed by Government and preparedness requirements directed by Chief of the Defence Force (CDF).

CDR Turner started his presentation by identifying how the force exploration office addresses future force development.

"Force exploration branch shapes the future of the Australian defense force by identifying changing trends, and conditions that can become capabilities that provide us with advantage. We do this by seeking to understand the future environment and providing a concept driven pathway to compelling future force options that generate and sustain military advantage out to 2040, and beyond. It's clear that robotics and autonomous systems will have a disruptive influence in the future operating environment."

He underscored that the force exploration branch released a report in December 2020 which identified how the ADF can "generate military power using robotics and autonomous systems."

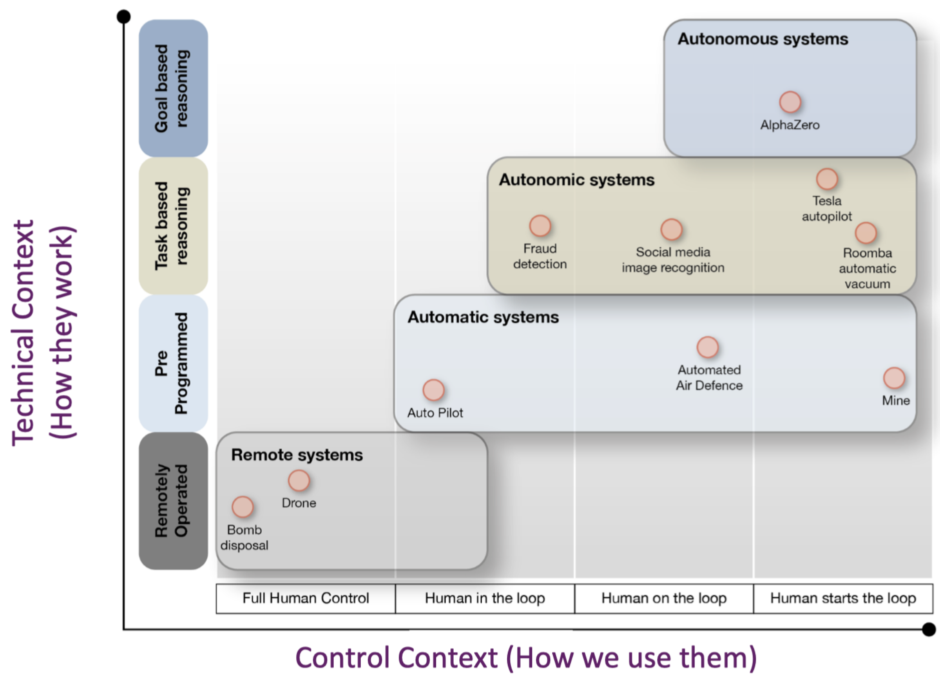
That report was built around the core concept that the autonomy and the artificial intelligence techniques that enable it should be understood from the standpoint of "the convergence of a broad range of technologies, some much more mature than others.

"These technologies include, power generation and energy storage, computation, swarming technology, advanced materials, nano explosives, biometrics, additive manufacturing, sensors and perception, and common control architecture, to name the key components. These technologies need to be harnessed and integrated to provide a reliable and effective capability."

For these technologies to be considered disruptive, they need to be mastered in such a way to give the ADF an operational advantage. And to do so in a way that the adversary's use can be countered and to do so in a way that gives the ADF an operational advantage. Or put another way, the adversary always gets a vote, and no new technology is introduced without an adversary working to counter it or to introduce new technologies which need to be countered as well.

CDR Turner provided a lexicon to understand what the various categories of autonomy are and how best to understand what the different capabilities are in order to understand how they might be used by the ADF. In the chart below, he highlighted how to distinguish between remote, autonomic, autonomic and autonomous systems.

He did so by placing these systems on two axes of development. The first context is the technical one or how they worked; the second was the control context or how we use them.



The first category are remote systems. These systems are those operated by humans via remote methods. They are already in service or being introduced into service, such as a bomb disposal remotely operated system.

The second category are automatic systems, which are preprogrammed to act in a deterministic manner. For example, "if a target is detected heading towards the ship faster than a certain speed and with a certain range, the system will engage it. A human operator may adjust the programming, but such a system will not improve its own behavior based on experience, these systems have been used by the ADF for many years."

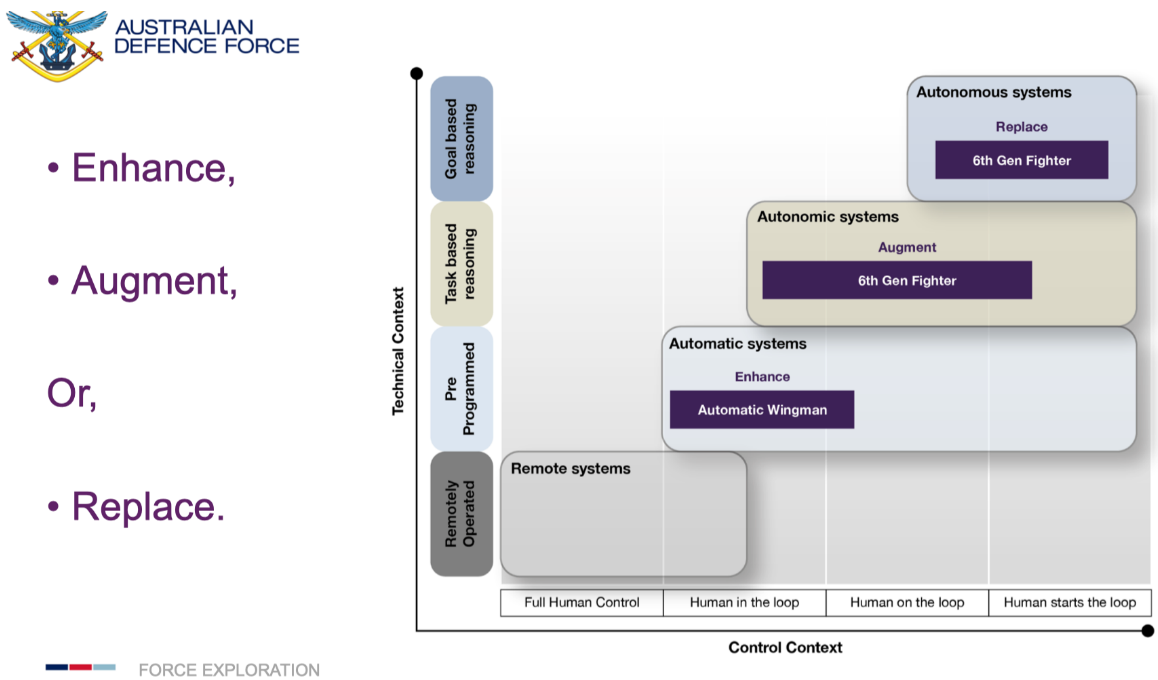
The third category are autonomic systems, such as the Aegis combat system. "Autonomic systems achieve human defined tasks by operating with reference to a set of predefined guidelines, respond to stimuli in a probabilistic manner. For example, an image recognition system is provided with the signatures of enemy vehicles…. A human operator can monitor the system to confirm that assessments are correct and provide more signature data to knowledge base. As the data grows, the system can improve its important performance of this task."

The fourth category are "truly autonomous systems that can learn from their data and their own processing to determine the tasks necessary to achieve a human defined goal."

And he added: "An example of a fully autonomous system may not yet exist."

With regard to future force capabilities, CDR Turner argues that "the autonomic and autonomous systems that will generate the greatest disruption systems that can perform tasks not suited to deterministic behaviors and can develop novel tasks and approaches to new tasks. "Such systems will enable us to create capabilities that merge human like characteristics with machine characteristics." If the ADF is focused on introducing such capabilities, it needs to consider whether such capabilities enhance, augment or replace current platforms and capabilities.

With regard to the longer-term future for the ADF, as autonomous capabilities become available, he argued that new approaches to shaping platforms will be required.



"Does this mean that we're looking to design a future force that contains autonomous F-35s, autonomous M1s, and autonomous DDGs? Adding autonomy to these platforms will certainly be part of their lifecycle upgrades, but we will not be able to take full advantage of autonomy if we do not consider how other technologies will converge into platforms that are designed from the outset to operate with less human input. These future platforms will be fast, accurate, stealthy and persistent in applications, not currently able to achieve such characteristics."

Underlying this projected transition is the question of data and its exploitation by the fifth generation evolving force. He did not put it this way, but it makes sense to focus on how C2 and information generated by Information, Surveillance and Reconnaissance systems are evolving within the context of force development now and in the mid-term.

The question is about the reliability of data and information and the trust which warfighters can place on data at the tactical edge as well as in providing for accurate tactical or strategic area wide decision making. CDR Turner clearly makes the point that the question of trust in data is the most challenging for future autonomous systems. "Autonomous systems create the greatest challenge for trust."

One could argue that the priority being given to shaping effective mission command for the integration of a distributed force already being shaped with the new generation of platforms, such as F-35s, P-8s and Tritons, lays a foundation for a way ahead. As CDR Turner put it: "With the foundations of data trust and command control in place, we can design capabilities to exploit autonomy by enhancing current capabilities, augmenting planned capabilities and replacing legacy systems with RAS."

He argued as did other speakers at the seminar that for the ADF enhancing the mass of the force to be able to operate over the distances challenging ADF operations was a key advantage of crafting autonomous systems capabilities which can be integrated into ADF concepts of operations.

"Autonomous systems are asked to increase their mass while even employing them in forward roles, or employing autonomy in roles that allow us to optimize our workforce. An autonomous Wingman is an example of a system that increases our mass forward, while autonomous resupply vehicles would free up personnel for other roles.

"Autonomy has the potential to achieve decision advantage and increase, not just the speed, which we can complete the decision-making cycle, but also improve the quality of decisions. Autonomous surveillance, data processing and decision support will allow commanders to understand and act upon battle spaces of increasing complexity and respond to adversaries also operating at machine speed. Autonomous systems will be part of the targeting process…"

But as CDR Turner put it earlier in his presentation: "An example of a fully autonomous system may not yet exist." What does exist if the transformation underway with regard to building out a fifth-generation force, one in which distributed forces and innovative task forcing is reshaping how the ADF operates. And that force redesign being worked in the operational force can provide the foundation for shaping a way ahead within which autonomous systems can provide ways to enhance, augment or replace platforms operating within the force.

And the presentation which followed that of CDR Turner, by Professor Jason Scholz provided further insight into how this transition might work.

THE ECO-SYSTEM FOR NEXT GENERATION AUTONOMOUS SYSTEMS AND SHAPING A WAY AHEAD FOR THE ADF

A key consideration at the seminar was how the ADF could leverage a broader ecosystem of change in the commercial sector where robotics and artificial intelligence were playing key roles.

The presentation at the seminar by Professor Jason Scholz, CEO of the Trusted Autonomous Systems Defence Cooperation Centre focused directly on this issue. Scholz is this year's winner of the McNeil prize, awarded to 'an individual from Australian industry who has made an outstanding contribution to the capabilities of the Royal Australian Navy', he is also a tenured Innovation Professor at RMIT University in Melbourne.

The broader Australian effort with regard to autonomous systems provides an opportunity for the ADF to shape sovereign defense capabilities in this area as well as working more effectively with relevant global partners in this area. And it is not simply a question of kit; it is about working ADF concepts of operations interactively with core allies.

As the ADF works its way ahead with regard to building out its fifth-generation force to enable integrated distributed operations, selective autonomous systems will enable the force to become more effective, more lethal and more survivable.

The Centre provides a catalyst for change. This is how the TAS website describes the organization:

Trusted Autonomous Systems is Australia's first Defence Cooperative Research Centre, and is uniquely equipped to deliver world-leading autonomous and robotic technologies to enable trusted and effective cooperation between humans and machines. Our aim is to improve the competitiveness, productivity and sustainability of Australian industry.

Supporting Australia's defence capability

Trusted Autonomous Systems, together with its participants and the Department of Defence, is developing the capacity of Australia's defence industry to acquire, deploy and sustain the most advanced autonomous and robotic technology through:

- ***delivering world-leading autonomous and robotic Defence technologies***
- ***building innovative IP through targeted research and technology programs***
- ***assisting Australian industry to develop new, improved and competitive autonomy technologies***
- ***evaluating the utility of autonomous systems through capability demonstrations.***
- ***Specifically, Trusted Autonomous Systems aims to:***
- ***develop highly self-sufficient and survivable systems ****
- ***develop highly self-determining and self-aware systems ****
- ***develop human-autonomy systems that are human and context aware***
- ***increase the speed to reach a deployable state for trusted autonomous systems***
- ***increase the scalability and reduce the cost of autonomous systems technology solutions***
- ***educate in the ethics and legal aspects of autonomous systems***
- ***advocate and form national policy and regulations.***

Supporting acceptance, regulation and certification of autonomy

In addition to specific industry-led Projects, TASDCRC is undertaking two common-good activities that have broader, non-defence applications, in addition to their defence benefit. These activities are the Ethics & Law of Autonomous Systems and Assurance of Autonomy.

Through these activities TASDCRC will:

- ***foster ethical and legal research including value-sensitive design***
- ***develop policy pathways for projects and participants***
- ***support development of Queensland air, land and marine ranges for trusted trials, test and evaluation***
- ***establish independent, world-class certification pathways for global industry.***

How we work

Trusted Autonomous Systems fosters collaboration between Australia's defence industry and research organisations and aims to increase small and medium enterprise participation in its collaborative research to improve the research capabilities of the Australian defence industry.

Established under the Next Generation Technologies Fund, with $50 million invested over seven years, and supplemented by other governmental funding, the Defence CRC aims to deliver trustworthy smart-machine technologies for new defence capabilities based on advanced human-machine teaming.

**** May be human piloted but never needs to be. If in trouble seeks human assistance. If assistance not forthcoming goes into a safe mode of operation.***

This is how Scholz described the challenge and the way ahead for the ADF in the autonomous systems area:

"Autonomous systems for air, land, sea, space, cyber, electromagnetic, and information environments offers huge potential to enhance Australia's critical and scarce manned platforms and soldiers, and realizing this now and into the future requires leadership in defence, in industry, in science and technology and academia with an ambition and an appetite for risk in effecting high-impact and disruptive change."

He underscored the crucial importance of leveraging the broader commercial developments and uses already underway. "We need a diversity of means to make this work. And it happened into the future. This is an initiative of defence and DST group. It leverages strong commercial technology drivers to solve these long-term challenges experienced by the department."

The Centre takes an approach which is "defence needs-driven," with every project clearly having to show how it can be a "game-changer for the ADF to fight and win." Projects are "industry led" often with smaller firms, to ensure new technologies get through the "valley of death." All projects are "research supported" which includes subcontracting government researchers and academics to industry – a novel approach.

I had a chance to discuss with Jason, to understand the nature of the way ahead in practical terms during a phone interview on May 27, 2021.

The focus of that conversation was very much on how to get these innovations into the hands of the ADF as operational capabilities as the ADF was working force transformation referred to as building a fifth-generation force.

Although autonomous systems can be labelled as disruptive technology, in actual fact, the disruption is already underway. What the ADF refers to as building a fifth-generation force can also be labelled as building a distributed and human-machine-team integrated force.

This is clearly underway with the platforms and systems which the ADF is already acquiring, but what next generation autonomous systems can do is accelerate the transition and build out greater mass for a distributed force. And as autonomous systems are leveraged, the way new capabilities will be added, and supported will change, including in terms of the industrial model supporting the force as well. For example, the ADF is operating a number of software upgradeable systems already, with the Wedgetail being the first platform introduced into the force which is built around software upgradeability.

With a manned system, obviously there is concern for the safety and security of the manned elements crewing the platform, so that software redesign needs to be done in regard to these key considerations. But as Scholz put it in our interview, with the Centre's focus on the "smart, the small and the many", compared with traditional "complex, large and few" manned systems, code rewriting can be much faster.

It is also the case that digital engineering and digital twins is changing how all platforms are designed and supported. But in the case of next generation autonomous systems, the entire life cycle of these "smart, small and many" systems is very different. "They will be attritable; there will be no need to develop and maintain 30 years of systems engineering documentation – some of these might be used only once or a few times before disposal. When you need to adapt to the threat, digital engineering supports fast redesign and T&E in the virtual, and to add a new capability you just download it as software." Scholz says.

And the question of how to handle the requirements process is very different. This already true for software upgradable platforms like Triton, but it has been VERY difficult for acquisition systems to recognize how software upgradeability simply blows up the traditional requirements setting process. Next generation autonomous systems are built around software and digital life cycles; this means that how they are validated and introduced requires a clearly modified acquisition approach.

I remember how difficult it was to introduce the Osprey into the USMC and then into the force. I interviewed a Marine in the early days of introduction, and he referred to the challenge of transitioning from being a "bar act" to becoming a core combat capability which significantly transformed the force.

Autonomous systems face the problem of moving from being a "bar act." So where might these systems be introduced in the near term, gain operator's confidence, and contribute in the short to mid-term to a more effective ADF?

The shortest path to escaping the "bar act" phase is in infrastructure defense. Maritime autonomous systems certainly could provide a significant contribution in the relatively short-term to something as crucial as extended port security and defense.

Indeed, Scholz worked with CMDR Paul Hornsby in the 2018 Autonomous Warrior exercise. According to Scholz: "This was the biggest trial of autonomous systems which the Royal Australian Navy has done to date. We had 45 companies actively participating with live demonstrations, as well hosting the final demonstration of the Five Eyes nations Autonomy Strategic Challenge which was an initiative of The Technical Cooperation Program (TTCP). We were able during the exercise to control 13 separate semi-autonomous vehicles, in the air, on the surface, underwater and on land simultaneously from a single operator at a workstation. One of the vignettes was littoral base defense."

He argued that for the ADF, a "human-centered, AI-enabled, internet of things" approach is a way to think of it. From our work with Second Fleet, VADM Lewis and his team are rebuilding their approach around mission command for a distributed force. This is the strategic direction already underway.

Scholz sees autonomous systems as providing mass to the distributed force. "Humans express mission command goals to machines, machines express to the operator what actions they can take to achieve that, and a contract agreement is formed. Within the commander's intent, machines then subcontract to other machines and so on, dynamically adapting as the battle evolves to build that Mosaic."

In both his presentation and our discussion, he highlighted a capability which they are working now which can provide for sensors and communications capabilities to support the force which complements manned assets to provide for Information, Reconnaissance and Intelligence. In other words, autonomous systems can provide for sensor networks which can be part of the effort to leverage information systems to deliver more timely and effective decisions.

"For example, high-altitude balloons can operate at 50,000 to 70,000 feet, above manned aircraft – largely solving the detect and avoid airspace problem. The endurance of these are a few days to weeks with the potential to station-keep or track surface targets with edge intelligence. The cost of these are a few thousand dollars each.

"They are reusable maybe six times, and can carry comms and ISR. Launch them in hours not like the months for cube sats. They are attritable, so you can put them in places you wouldn't put other assets. They can assist first responders or support to war fighters."

In short, the ADF is already undergoing a transition to shaping a distributed integrated force. Next Generation Autonomous Systems can provide a further set of capabilities for a more effective, dense, survivable and capable ADF as it builds out for operations in the Indo-Pacific region and enhances its defense of the Australian continent.

THE AUSTRALIAN ARMY, NAVY AND AIR FORCE SHAPE A WAY AHEAD FOR THE INCLUSION OF AUTONOMOUS SYSTEMS

At the Williams Foundation seminar each of the service chiefs provided their perspective on the way ahead for their service with regard to such systems.

As WGCDR Keirin Joyce, the Seminar's moderator, noted during the Seminar: "All of the services see robotic autonomous systems as a significant part of the road ahead. It's just that the services are getting after them differently."

Even though the strategic way ahead is shaping a force able to work across service platforms to deliver the desired combat or crisis management effects, each domain has a physical quality to it different from the other domains. And autonomous platforms like any platforms have to respect the domain within which they operate. And so doing, they might well be able to contribute to platforms operating in other domains, but they must first of all work effectively within a ground, air or naval combat force.

The Australian Army and RAS

With regard to the Army, the ability to experiment is significantly greater than with the other two services. The cost to do so and the fratricide which such systems can introduce into the operational force is much less to do so. There is little doubt that introducing such systems into near term operations, such as logistical support for HADR operations make a great deal of sense and can provide the force with near term learning from which to generate a broader capability to use such systems.

In an August 9, 2020 video, the Army put its case succinctly in highlighting an optionally crewed autonomous casualty evacuation vehicle (OCCV): "The Australian Army will increase its experimentation, prototyping and exploration of autonomous vehicles and emerging technologies through Defence industry contracts valued at $12 million, allowing Army to learn, prototype and develop future concepts. Technology such as Robotics, Autonomous Systems, and Artificial Intelligence act as a force multiplier, and the mastery of the technology will make us more effective on the future battlefield and help to keep our personnel safe."

Lieutenant General Rick Burr, Chief of the Australian Army, underscored the work Army is doing to introduce autonomous systems and to integrate them into the force. The Army's overall approach is described as accelerated warfare within which autonomous systems are developed and assessed as contributors to enhanced capabilities, like all platforms and systems are as well.

They are part of being what he calls having a force which is "future ready." The inclusion of intelligence learning machines will contribute to what the Chief refers to as his approach to shaping the Army as a "force in motion." He argued that Robotic Autonomous Systems (RAS) can maximize solider performance, improve decision-making, generate mass and scalable effects, protect the force and enhance efficiency.

Today, Army is the largest user of uncrewed air systems. The Chief argued that uncrewed ground systems in the future will proliferate in a similar way. "Greater use of autonomous systems will be a feature of future ground forces."

An important point which he highlighted was that in making capability investment decisions are being done with regard to their ability to incorporate or work with RAS. For example, with regard to the future infantry fighting vehicle, the Army is focused on that vehicle able to operate with RAS, including controlling several smaller autonomous vehicles as well. "The vehicle will have the power and computing potential to operate numerous, smaller uncrewed and autonomous systems."

In the Army Chief's approach, autonomous systems are part of the future force, but part of force being driven by a number of technological developments. "Greater platform collaboration, new power sources, new forms of active and passive protection, more lethal strike weapons, and directed energy weapons, are examples of this way ahead."

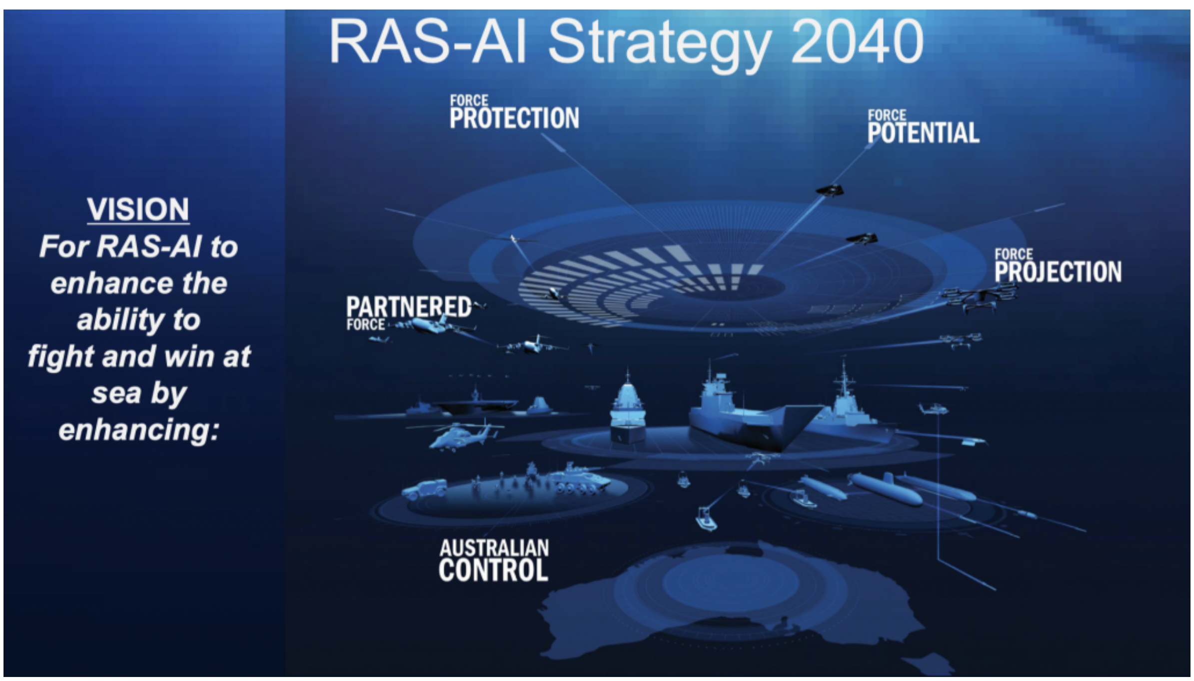
He underscored that in the future "Army's teams will be more connected, protected and lethal so they can achieve their missions against current and emerging threats at the lowest possible risk to Australian soldiers."

He argued that the force as it modernizes is examining throughout this effort new opportunities for the use of RAS in the force. For example, "our aviation crews are examining the opportunities for manned-unmanned teaming, notably as we look forward to the delivery of the new attack helicopter."

The Army chief highlighted the nature of the globally competitive environment where maintaining an edge is both more necessary and more difficult. He argued that such a competitive edge could accrue to the ADF to the extent to which the force can be better integrated and coordinated than its adversaries. This requires superior training and decision-making capabilities. This is why, he argued, why people is at the "center of our efforts. It is people that get the technology working effectively in the dangerous and contested environments."

The Royal Australian Navy and RAS

The Chief of Navy, Vice Admiral Noonan, discussed the Navy's RAS-AI 2040 strategy which he had introduced last year. As he described that strategy: "The way that we've sought to visualize this vision is through five very fundamental effects. Force protection, obviously all about keeping our people safe and out of harm's way so that they can get on and do their job. Force projection is about how we can achieve mass. Force potential using human machine teaming, ultimately to achieve better and more effective decision-making in the war fighting effort. Partnered force concept around how we will operate as an integrated and joint force by design."



Vice Admiral Noonan then discussed the six principles which underly the RAS-AI Strategy 2040.

"The six fundamental principles were built around a user centered design. The system design is user centered. In terms of decision support, we are looking to have systems that significantly reduce the cognitive load on our commanders and operators alike, allowing for them to achieve greater shared situational awareness to deliver effective, efficient, and ethical decision-making.

"The joint integration piece is critical. I cannot stress that highly enough in terms of we must ensure that these systems are integrated. Not just integrated into the platforms or their parent platforms but integrated into the force.

"And they are capable of being evergreen. This is the new term for spiral development. It's about ensuring that we have systems that remain contemporary, and I am challenged on a daily basis about capability gaps and about deficiencies in the long lead times that require us in the shipbuilding space. It takes about 10 years to build a submarine, or five years to build a frigate.

"And are we incorporating old technologies? Bottom answer is no, in that we are designing future and evergreen in growth into our platforms. And I think that's a very important concept that we have not always fully grasped.

"Finally, is the importance of made in Australia. Our systems must be designed for the very unique circumstances that we operate in, particularly in the maritime environment."

Vice Admiral Noonan then highlighted really the key aspect of using any new sensor networks, whether they be autonomous or not, namely, their integration into a C2 system. "Operating all these systems would simply be too complex, too time consuming and ultimately unmanageable without a common control framework. Therefore, as part of the way that we seek to get after that, the building blocks of that framework, as we see them in Navy, it needs to be a legal and ethical module that allows us to have embedded and encoded regulatory and legal protocols. Clearly a common control protocol that unifies the means of machine control.

"We need common control bridges that provide an interface between the proprietary control systems and the combat management systems of the platforms from which they're housed. We need a common control language that can express C2 in a way that both human operators and RAS-AI machines can understand. And ultimately, we need a common spectrum management protocol, levering and integrating programmed projects to harden and ensure the spectrum in which we operate."

The Royal Australian Air Force and RAS

The RAAF has already acquired two flying platforms which are designed to work together in a manned-unmanned teaming effort, namely, the P-8 and Triton. These platforms for the U.S. Navy working with other platforms, such as the Romeo Helicopter are providing important real world operational lessons with regard to shaping a foundation for the future.

In addition, with the loyal wingman program underway, the RAAF as one of the most advanced air forces in the world, we introduce the loyal wingman into a force already being reworked with the introduction of the F-35. The challenges to introduce Loyal Wingman and then to use it effectively will be an important part of shaping a way ahead for autonomous systems in the airspace.

At the seminar, Air Marshal Mel Hupfeld provided the RAAF perspective on the way ahead in this area of development and operations. At the outset of his remarks, he noted: “Defense can gain significant advantage through leveraging autonomous systems, that's to make better decisions faster, to more effectively allocate resources, and to discover new ways of delivering military effects. Artificial intelligence and human-machine teaming will play a pivotal role in air and space power into the future.”

The RAAF is working a way ahead with regard to integrate manned new and existing aircraft with remotely piloted and autonomous systems. A key case in point is Loyal Wingman. According to Hupfeld: “The true value is indeed hidden inside the airframe of Loyal Wingman. And that is the development of the code and the algorithms which form the artificial intelligence behaviors that will optimize its combat capability. The Loyal Wingman project is a pathfinder for the integration of autonomous systems and artificial intelligence to create smart human-machine teams.

“The aim is to provide capability advantage, working alongside existing platforms to complement and extend our air combat platforms and our other systems. And we're exploring totally new concepts of operations, whereby multiple systems will pair with crude capabilities, such as the F-35, the Growler, the E-7 Wedgetail, with an aim to bolster our relatively small but potent Air Force.

“And it's clear how this changes things for us. Such an asset will change the way we calculate risk. The Loyal Wingman is the giant uncrewed gorilla in the room, but we've got many other programs that don't immediately catch the eye. And these programs, though less visible, will no less revolutionize the way we do business.”

He underscored that the Plan Jericho program through the Jericho Disruptive Innovation effort is looking at ways of automation and artificial intelligence that can step in to help pull the weight. There are still jobs in Air Force that we have people performing which are predictable, repetitive, and they don't require creativity. “But this is not about replacing people with machines. We've got a shortage of people and they're a scarce resource. And our work in this space is really about freeing up those people so that we can employ them in those areas that humans do best.

“In my view, one of the best examples of this theory at work is some work we're doing, once again, through the Jericho program, on quarriable sensors program. Now, while we would probably work on a catchier name, and hopefully one that's easier to pronounce, what this project is seeking to achieve has the capacity to force-multiply our intelligence surveillance and reconnaissance capability by a factor of two or three….

“I believe that our sensors are currently employed very inefficiently. So for example, most of what our sensors stream is meaningless noise, and even when we do capture important information, it's not necessarily available to the people that need it. The quarriable sensor program takes care of all this by using artificial intelligence and machine learning to automatically detect when an event of significance occurs. It will then report that directly to commanders and decision-makers in real time, enabling the customer to determine whether the automated response and the intelligence is valid.”

Air Marshal Hupfeld provided a good summary to the day and to the presentations of the Service Chiefs. "We're disappointed in reporting that we see from some of our commentators who still choose to discuss Air Force capabilities in isolation. Whether or not Super Hornet can breed another capability one on one is really, to me, not a useful conversation. The force of tomorrow will be characterized by those invisible connections across air, land, maritime space and cyber, with masses of data from sensor inputs being fused, using artificial intelligence and machine learning, to rapidly convert data to information, to knowledge, to insight, all at unfathomable speeds.

"The entire Defence Force will be one integrated system of systems. My vision for automation is that the joint force will be AI-enabled using robotics to augment roles, and humans working with machines, so they get the best out of both. The days of boring menial tasks will be gone. Our most scarce resource, our people, will focus on higher value and the creative tasks that we need.

"And with this vision, we'll march in lockstep with our colleagues in Navy and Army and across Defense to ensure that we deliver an autonomous future, and the responsiveness and precision of air and space power that we need, into our future joint force."

DEFENCE INDUSTRY AND WORKING WITH DEFENCE IN SHAPING A WAY AHEAD FOR AUTONOMOUS SYSTEMS

The development and incorporation of autonomous systems into the Australian fifth-generation force requires a close working relationship between defense industry and the Department of Defence and the services.

But it also requires meeting the challenge already seen with regard to the introduction of software upgradeable systems such as F-35, P-8 and Triton. That challenge is for the warfighters to be able to drive advantages through rapid code rewrites and being able to develop and generate with the autonomous systems advances, disposable systems as well.

This was well put in the discussion with Jason Scholz. As Scholz put it in our interview, with the Centre's focus on the "smart, the small and the many", compared with traditional "complex, large and few" manned systems, code rewriting can be much faster.

It is also the case that digital engineering and digital twins is changing how all platforms are designed and supported. But in the case of next generation autonomous systems, the entire life cycle of these "smart, small and many" systems is very different. "They will be attritable; there will be no need to develop and maintain 30 years of systems engineering documentation – some of these might be used only once or a few times before disposal. When you need to adapt to the threat, digital engineering supports fast redesign and T&E in the virtual, and to add a new capability you just download it as software." Scholz says.

At the seminar, there were presentations by five industrial partners. Boeing Australia focused on the development of the Loyal Wingman. With the space which Australia has along with the technical capabilities in the country, Australia is in a good position to be a leader in autonomous systems. According to Andrew Glynn, Boeing Australia, the Airpower Teaming System, which has been established to develop loyal wingman is an important approach to shaping a way ahead. He noted that "the loyal wingman program is an experimentation program with RAAF to provide insights in the use for this type of capability." Clearly, from Boeing's perspective, the standup of the program in Australia is not simply about meeting the ADF needs, but provides a launch pad for broader global development.

Glynn underscored that the teaming approach is designed to develop capabilities which can work with existing fleets. “Once ATS is operational, it will assist the RAAF to protect and project force by addressing quantity at the right quality.”

He noted that the program went from concept to first flight in under three years and that was enabled by the fact that the platform is built on a completely digital foundation.

A second presentation was given by Dr. John Best of Thales, Australia. In his presentation, he focused on the opportunity to build or enhance sovereign defence capability built around autonomous systems. But to do is not just an industry challenge, it is in his words “an enterprise challenge.” What is required is defence and industry to shape an ecosystem where they can work together to deliver the desired outcome. He also underscored that Australia has the building blocks in place to deliver such a solution.

A particularly important aspect of shaping a way ahead is to shape more effective ways to manage complex systems, and within that context the autonomous piece of complexity. And the continuous learning piece which comes from use in the real world of combat and gray zone operations needs to be fed into the evolution of systems, This means that the “learning piece” needs to be worked into the contractual relationships which industry has with Defence.

A third presentation was by Dr. Andrew Lucas of Agent Oriented Software. He provided a very helpful clarification of how autonomous systems are different from automatic or automated systems. For Lucas, an autonomous system is goal directed and capable of rational reasoning with regard to those goals. An autonomous system can perceive its environment, determine if the environment affects its goals and then takes actions in alignment with its goals up against the operational environment. It is able to balance proactive and reactive behaviors. This is in contrast to automated system which simply follows a task list or script.

He then provided a way to look at the evolution of autonomy within the context of man-machine operations. His schema is built around the axis of increasing levels of delegation to the system. It moves from the machine simply providing timely advice with the humans making all the decisions; to a semi-autonomous relationship in which the machine is subordinate to a certain level of human authority; and then operating fully autonomous in which the machine operates without huma control or direct oversight.

Dr. Lucas then discussed the relationship between AI and autonomous systems. AI is defined by him as the “theory and development of computer systems able to perform tasks normally requiring human intelligence.” AI enables machine learning which is to be understand in terms of “a computer program can learn and adapt to new data without human intervention.” And this then enables to creation of intelligent agents which can be defined as “a computer program that is capable of perceiving and interpretating data sensed from its environment, reflecting events in its environment, and taking actions to achieve given goals without permanent guidance from its user.”

He underscored that to achieve the capability for autonomous systems, several trend lines in the evolution of AI and machine learning need to coalesce or synthesize. From this point of view, he noted that there were several AI trends, thrusts and directions which are shaping a way ahead. These included image analysis and recognition, or sensor identification and assessment, speech recognition and the ability of the human and machine enablement of dialogue, intelligent search and assessment, and intelligent software agents able to work through big data. With such capabilities evolving then situate AI and robotics are enabled with the possibility of machine learning.

In other words, there is clearly a pathway already being shaped to autonomous systems, but investments, experimentation and development remains. And he argued that Australia needs to invest in this development to deliver on the promise of autonomous systems both for the civil and defence sectors.

A fourth presentation was by Northrop Grumman, but done by remote participation from the United States. Northrop is a key player in Australian defence, and in the area of man-machine teaming, clearly the arrive of Triton is part of the way ahead. But the key focus which the company has upon expanding the types and nature of sensor networks and finding ways to leverage those networks to deliver timely decision-making data is a key part of the way ahead.

Clearly one way already that Northrop is contributing to such a way ahead is with regard to how the F-35 functions as a C2 and sensor "flying combat system" and enables it to fight in an 8-ship formation as a wolfpack. This was not mentioned at the seminar but clearly is a key enabler of the way ahead for the ADF which also provides a foundation for shaping the broader efforts to shape an integrated distributed force able to work a diversity of sensor and communication networks to deliver the desired combat effects.

In the Northrop Grumman presentation, a key point is to shape a way ahead for battleship control where sensors can track operations within that battlespace. Clearly, remote sensors are proliferating and the importance of AI and autonomy for helping the tactical and strategic decision makers to que systems to perform key and dynamic tasks will become increasingly important in the extended battlespace.

A fifth presentation by defense industry was given by Air Vice Marshal Bill Henman (Retd), who is currently a strategic advisor Air and Space for Raytheon Australia. His presentation focused on a key issue, namely, the countering of autonomous systems. This subject is a key one both in terms of understanding how adversaries are using their own automated systems, which needs to include not simply the question of technology but concepts of operations, which in turn allows you to examine the vulnerabilities of your own systems.

Autonomous systems have vulnerabilities which can be built around spoofing, data corruption as well as braking effective sensor network to C2 communication flows. At the heart of the autonomous system impact is the control challenge. Henman defined control as "enabling friendly manoeuvre while denying adversary manoeuvre. He argued as well that control also involves deconfliction of friendly manoeuvre in terms both of kinetic and non-kinetic fratricide.

In his presentation, he highlighted how autonomous systems can be disabled or eliminated in combat. This can happen by disrupting or spoofing the detection and tracking systems. Or this can happen through various softkill options, such as jamming and spoofing, electronic attack or cyber intrusions. He then highlighted a number of hardkill options both kinetic (close in weapons systems) and non-kinetic, notably high energy lasers and directed energy systems.

These vulnerabilities clearly provide a realistic cautionary note to how autonomous systems can be introduced and used. And this is why their introduction into infrastructure defense such as extended port security or into logistical support, up to and included logistical management systems, are good places to start and to sort through how to do so enhancing rather than compromising national defense and security. `

He ended his presentation by proposing a number of key actions as the way forward with regard to autonomous systems is worked. First, it is important to create the optimum environment to allow industry, Academia, Research and Development communities to be able to create and field innovative control soltuions. Second, it is crucial to be able to understand the operational implications of an adversary who has greater freedom of manoeuvre with respect to all dimensions of governance of autonomous systems than do the liberal democracies. Third, there needs to be as much focus on the development of superior autonomous decision cycles as there is upon the development of the sense and respond control systems enabling autonomous systems. And finally, he argued for shaping autonomous decision making 'tutorship' in roder to build the future confidence needed to send autonomous systems into combat as the force evolves with more agile, multi-domain C2 capabilities.

A final defense industry presentation was by Lockheed Martin Australia. Dr. Tony Lindsay, formerly of the Australian Department of Defence's Department of Science and Technology or DST, provided insights as well.

Lindsay provided an overview on the decision cycles for the force and how autonomy might provide both enhancements to such decision making as well as more capability to leverage the proliferating sensor networks.

He argued that AI and autonomous systems have the possibility for impacting on all parts of the decision cycle, such as persistent ISR, sensor cuing, scene understanding, and cognitive battle management. They could just as well undercut decision effectiveness if not worked into an effective decision-making cycle. This requires allowing the operator to act using relevant information, be able to align with commander's intent and provide for system adaptation.

The broader shift associated with the fifth-generation force transformation, namely distributed force which can be scalable and integratable provides a solid foundation for managing proliferating sensor networks as well as finding ways to use autonomous systems within distributed decision-making systems.

In short, shaping a new enterprise approach already underway driven by software-upgradeable systems, and reworking how platform providers work with the forces and defence, presages the significant changes underway into which autonomous systems will be introduced and integrated within the force.

SHAPING THE ECO-SYSTEM FOR LOGISTICS INNOVATION: THE IMPACT OF AUTOMATION AND AUTONOMOUS SYSTEMS

Col. Beaumont, Director of the Australian Army Centre, focused on the intersection between logistics and support innovation and automation and autonomous systems

An expanded article which encompasses his presentation can be found in the appendix to the report.

Much like Marcus Hellyer did in his presentation to the seminar, he argued that autonomous systems are not ends in and of themselves but must be seen as part of a wider force structure modernization effort.

He warned: "It is important to be aware of the risks. Cyber threats are persistently targeting global businesses, so Defence must prepare itself during the transformation of its logistics capability." Aware of the risks, how do we shape a way ahead for transformed logistics?

I had a chance to follow up with Col. Beaumont during a phone discussion in April 2021 to discuss how he saw the way ahead. It was clear from looking at his presentation that Beaumont highlighted the role of better information systems and the internet of things as a core way ahead to shape a more effective logistics support system.

As Beaumont started the discussion: "The new automation and autonomous systems technologies offer great promise and provide valuable tools which will be adopted more widely over time.

"You don't want to get seduced by technology to the point that you're taken down some rabbit warrens that create risks in themselves. I see automated tools as providing for serious strategy change in a relatively short period of time, rather than overemphasizing what autonomous platforms can quickly provide."

By shaping more capability to use information tools, automation tools associated with the Internet of Things allows is for reshaping the template for logistics support. As that template is worked, the ecosystem is created within which further ability to leverage next generation automated systems is enhanced. It is a question in some ways of putting the cart before the horse.

Beaumont highlighted that "even as simple an effort to implement enterprise business tools but to do so within a deployable system is a key advancement which allows us to shape a more effective way ahead. In large part it is about building sensor networks within an overall logistics system and finding ways to tap into those networks to provide for more effective decision support and for these new systems to enable better domain knowledge throughout the logistics enterprise. It is about taking those sensor networks and having the computing tools which enable you to be able to rapidly predict or act without direct human intervention to enable decisions with regard to doing the right thing in the right place at the right time to support the force from a logistics point of view."

His focus clearly is upon shaping a logistics enterprise system which can use automation and information more effectively to drive better tactical and strategic decision making with regard to logistical support. What we have already seen in practice is the challenge of overcoming cultural and organizational barriers to do so. We have seen in some militaries over-reliance on commercial IT systems which leaves their logistics system vulnerable to adversary cyberattacks. We have seen in the case of a new enterprise support system like the F-35 resistance to change in order to use the information generated by the enterprise system to change the configuration of logistics support itself.

As Beaumont put it: "To use a new system effectively, you have to develop the processes that truly can leverage the new system. One has to combine all sorts of different organizational factors to get the innovation which new technologies for support can provide, whether that be organizational redesign, or making sure the right people are trained to do it, and different specialties may be required as well to leverage the new technologies as well."

New technology is not a bromide that solves anything. You actually have to think about usability to the force. You have to think about finding ways that technology actually empowers the force rather than just simply disrupts it. It is often called disruptive technology, but that's not a positive thing if it's so disrupts if you have actually reduced the capability of the force to fight. That's hardly innovation.

We then turned to the question of how autonomous systems could be introduced into the Australian Army with a real benefit for the force and expanding its operational capabilities. From the logistics side, the challenge is two sided – how do you bring these assets into an operational environment? How do you service them? How do they help rather than burden the force? How can they provide logistical support for a deployed force most effectively?

The Australian Army is certainly experimenting with a number of autonomous systems, but the logistics side of this is a key part of shaping the way ahead, both in terms of enhancing the demand for logistical support and providing for logistical support.

We discussed one area where it might make a great deal of sense to get the kind of operational experience where such systems could be introduced and supported without introducing excessive risk to the combat force, namely, in support of HADR missions. A HADR mission involves moving significant support forward from either an air or sea delivered force. How might autonomous systems be used to assist in moving relief supplies to the right point and the right time? How might deployable "internet of things" automated information systems be set up to manage the flow of supplies to the right place and at the right time?

Beaumont noted that at the Williams Foundation Seminar "there seemed to be a wide consensus upon the importance of experimenting with these new systems to determine how best to use them."

In short, Beaumont highlighted the near-term opportunities to use new enterprise system approaches and technologies to reshape the logistics enterprise system and in so doing shape the kind of template which was conducive to further changes which autonomous systems could introduce.

THE INTEGRATED DISTRIBUTED MARITIME FORCE: THE IMPACT OF MARITIME AUTONOMOUS SYSTEMS

In an interview with Vice Admiral (Retired) Tim Barrett, there was a chance to discuss more fully the evolving approach of Navy to the way ahead with regard to autonomous systems.

The discussion obviously built upon the presentation of Vice Admiral Noonan, Chief of the Royal Australian Navy. As mentioned earlier, Noonon provided his perspective on the way ahead for maritime autonomous systems in the build out and evolution of the Royal Australian Navy. At the heart of his presentation was an opportunity to discuss the Navy's new Remote Autonomous Systems-AI 2040 strategy. As he put it: "Our Navy has already begun a journey to shape the maritime environment.

"To deter actions against our national interests. To respond with credible Naval power. To use robotics, autonomy, and artificial intelligence. Employing ever more reliable, robust, and repeatable systems. We will continue to drive our edge to help keep our people safe. To create mass, tempo and reach at sea and in all the lanes to enhance the joint force and strengthen our coalition with human command and trusted machine control. Our technologies, enabling our people to thrive. Our people, using technologies, to make smarter systems and better decisions."

The RAS-AI strategy is focused on enhancing the fleet, not supplanting it. And he underscored that the Royal Australian Navy is working currently to introduce these technologies into the fleet.

I have argued elsewhere that that shift in manned platforms to relying on software upgradeability as a key driver for ongoing modernization clearly becomes a central piece in understanding how to build out RAS-AI capabilities for the maritime autonomous systems platforms or assets.

The Vice Admiral introduced a very useful term which covers the way ahead for thinking about integratability across the crewed and uncrewed assets in the force. As he put it: "Evergreen, I think is the new term for spiral development. That's the way I look at it. It's about ensuring that we have systems that remain contemporary, and I am challenged on a daily basis about capability gaps and about deficiencies in the long lead times that require us in the shipbuilding space.

"It takes about 10 years to build a submarine, or five years to build a frigate. And are we incorporating old technologies? Bottom answer is no, in that we are designing future and evergreen in growth into our platforms. And I think that's a very important concept that we have not always fully grasped."

I had a chance to further discuss how to think about the way ahead for maritime autonomous systems within the fleet with Vice Admiral (Retired) Tim Barrett. I have been in an ongoing discussion about maritime matters with Barrett ever since I first met him in 2015, and as a key architect for shaping the build out of the 21st century Royal Australian Navy. I wanted to focus on the interaction between the new build strategy for the Navy's surface and subsurface platforms and the introduction of autonomous systems into the fleet.

Vice Admiral (Retired) Barrett is currently on the board of a key player in shaping a way ahead for autonomous systems, both in the civil and military sector. The CEO of that organization, Trusted Autonomous Systems Defence Cooperative Research Centre, presented at the seminar and I am focusing on his overview of the organization and his perspectives in a separate piece.

Jason Scholz, CEO of TAS, highlighted the purposes of the organization as follows: "Advance trusted autonomous systems technologies for asymmetric advantage so the ADF can fight and win; Create & foster game-changing research, of world standing, that pushes theoretical & practical boundaries of future trusted autonomous systems; Deliver autonomous systems & robotics technology with clear translation into deployable defence programs & capabilities for Australian Defence; and Build an environment in which Australian industry has the capacity & skills to deliver complex autonomous systems both to Australian Defence & as integral members of the global defence supply chain."

This means that Barrett brings to the discussion a deep understanding of the challenges of building out the RAN's surface and subsurface fleet with the coming of new autonomous technologies.

The challenge of course is to shape an approach which allows for their integration and dynamic processes of change over time. The core point which Barrett drove home in our conversation was the key challenge of building out the integrated distributed force with an open aperture to inclusion of the force enhancement capabilities which maturing autonomous systems can provide.

He argued that at TAS the focus was not just on the next big thing as how what developers can bring to the party which can enhance the capabilities of the force. As he put it: "the new technologies need to be fitted into a broader operational environment. The force has to fight tonight; how can we shape ways ahead which lead to force enhancement?"

In focusing on the subsurface domain, he argued that the context for submarines was changing significantly. They are increasingly operating in a broader kill web environment and need to be able to tap into trusted data to aid their operations and focus their efforts. Clearly, autonomous systems can play an increasingly role in mapping and tracking the undersea domain, and the manned assets become much more capable as trusted data networks can be tapped into.

As he noted: "Submarines are part of the undersea domain battle. They are key contributors, but they have to work within an integrated and distributed mode, which provides them with the information and context in which they can best operate and enhance the operational outcome."

Evolving autonomous systems will be able to provide enhanced undersea domain awareness which will then enhance the capability of the force to execute their operational plans more effectively.

But this leads as well to reinforcing the broader challenge facing the force: How do you manage and distribute the data being generated to provide information for tactical decision making at the edge and for broader tactical theater wide decision making?

And this leads Barrett to his version of Occom's razor when assessing what a particular autonomous system might contribute to the force: "I'm less interested in what the particular device being proposed – whether it is a swarming device, an undersea array or a sea glider — but I'm more interested in how your device obtains data, and how reliable it is and how to distribute it and how relevant it is or is not to the commander fighting the battle in operational space in which he is operating."

Notably, how do autonomous systems close gaps in the information-decision dynamic within which forces can operate as an effective kill web? Answering this question is not a one-off platform decision; it is an evolving modernization effort in which the challenge identified by Vice Admiral Noonan needs to be met of working an evergreen force.

THE QUEST FOR NEXT GENERATION AUTONOMOUS SYSTEMS: IMPACT ON RESHAPING AUSTRALIAN DEFENCE FORCES

The moderator for the seminar was WGCDR Keirin Joyce and an interview with him after the conference provided an overview with regard to thinking about the way ahead for autonomous systems in the ADF.

I had met Joyce at an earlier Williams Foundation presentation on unmanned systems and had a chance to follow up on his take on the issues discussed at the seminar in a phone interview on May 14, 2021. When I first met Joyce he was in the Army working on unmanned systems; now he was working Triton and Sky Guardian. He has served for 24 years in the Australian Army, where he last served as Program Manager of Unmanned Aerial Systems from December 2016-January 2020. Since then, he is serving in the Royal Australian Air Force as Chief Engineer for Royal Australian Air Force Remotely Piloted Aircraft Systems / Unmanned Aerial Systems at ISR Systems Program Office, including MQ-4C Triton under Air 7000-1B and MQ-9B SkyGuardian under Air 7003.

Precisely because he has been involved with two services and is knowledgeable with regard to the civilian side of artificial intelligence and robotics, he was the perfect choice to be the seminar moderator.

During the seminar, he highlighted an example of how current forces can use new unmanned technologies to support the evolving kill web, in which a small team with ISR and C2 capability can inform a firing solution by a virtual task force firing solution provider. mWGCDR Joyce noted that in an Exercise Hamel held in 2018, a two-man Army team using a Black Hornet Nano UAV were able to identify a tank formation, and then with their radio able to pass that information on to the RAAF for a strike opportunity against that tank formation.

This example highlights certainly one role which unmanned systems can play in providing ISR better labelled as information than intelligence surveillance reconnaissance because in this case you have the two-man team inside the weapons engagement zone (WEZ) providing input to an external provider not organic for a firing solution.

The first issue we discussed was the importance of understanding the challenge of generating innovation associated with autonomous systems into the operational military. The military as an organization is often described as risk averse, but since the military has to be prepared to fight tonight, disruptive change for its own purpose can degrade military capabilities rather than enhancing them.

The ADF has been described through Williams Foundation seminars since 2014 as building a fifth-generation force. In my own words, I see this as shaping an integrated distributed force through which kill webs can operate to provide for a scalable combat force.

With such a template, the role of next generation autonomous systems can enable either enhanced mass to modular task forces, or enhanced decision-making capability either at the tactical edge or at the wider tactical or strategic decision-making levels. As Joyce put it: "we know that we have to go to war with what we've got. When you go to the next big thing in defense, you proceed from what you already have."

The second issue was the key role in which Australia finds itself with regard to working next generation autonomous systems. As Joyce noted: "We are recognized as a global leader in autonomy in the mining and resource sector, both ground and aerial survey autonomy. I think a lot of that technology is able to be brought across to defense or upscaled towards defense applications."

As a key member of the five eyes community, Australian innovations have a wider market for both development and deployment. Australia also can draw upon innovations being shaped by the other five eyes members, and as Canada, the UK, and the U.S. particularly do not have the same geographical defense needs, there will clearly be different approaches to incorporating next generation autonomous systems into their forces. As Joyce underscored: “I think there is a melting pot of technology built in Australia that we’re good at and we have a lot of potential to contribute on a global scale.”

The third issue is the cross between the first and second points: Australia is already building a fifth-generation force which enables further innovation as well. With regard to the fifth-generation force, the core role of software has clearly emerged as a key element of change. As forces get more used to how to manage software upgradeability in current platforms, a learning cycle is being shaped whereby systems which are built primarily around software – the next generation autonomous systems – will become key elements for force transformation.

With the shift to the digital native generation of warriors, innovation processes are changing as well. WGCDR Joyce used the example of the potential impact of drone racers on military innovation. “The Drone Racing Teams of the Army, Navy, and Air Force are a key force for change. These are kids that have decided to take up drone racing in their spare time. None of them are employed to do this full-time. They have taken it off as a hobby and not through university, not through technical college, but off You Tube videos and collaborative communities that have taught themselves all the skills on how to build a UAV. They literally learn it all on You Tube, and they have this amazing skill set that sits at a peer level and in some cases in advance of our socially qualified engineers.

“In Australia we’ve used these drone racing pilots in support of our weapon’s technical investigations and intelligence, in support of rapid prototyping, assisting with ground autonomy trials, and all of these soldiers and aviators are doing this in their spare time.

“I think it’s something that we need to tap more and to develop deployable rapid prototyping labs, or deployable space labs. In the future it’s plausible that when we are confronted with the next asymmetric threat that our opposition force comes up with, there is absolutely the possibility that we can design, prototype and manufacture solutions, not by engineers, but by people who just know how to do it and have taught themselves how to do it because it’s fun. I think that is a real skill set that we should be focusing on and tapping: it is an opportunity that costs next to nothing.

“Perhaps we should be setting up structures in our organizations where we let these people do their day job one posting, and then on the next posting their whole job is just running or contributing to innovation labs. And then they go back to their job, and then they go back to the innovation lab. We could really foster those skill sets and thought processes and innovative approaches to whatever sixth Gen is, because when we take our Fifth-Gen Force to the next battle, we go with what we’ve got.

“And if we want to rapidly uptake that force to a Generation 5.1, or a Generation 6 application, then we are going to need skills to do that. Most of the skills needed are in code, in electronics, software, and in data: drone racers.”

The fourth issue is the relationship between the broader ecosystem for robots, AI and autonomy and finding ways for the military to tap into that broader ecosystem. WGCDR Joyce underscored how important being able to do so was for the Australian military and he provided an example of such a case.

“One case study in particular is prototyping an aircraft for the eVTOL market for unmanned aerial taxis. There’s a company out of Sydney called AMSL. They’re doing it for the commercial market. But they have partnered with Defence to take the five-passenger seats out and design a configuration for us to do 500 to 600 kilograms worth of combat resupply.

“We have asked them as well to do the design work that when that airplane is otherwise coming back empty from doing a resupply that we could also put in up to two stretchers for casualty evacuations. They are already doing the collaborative research with telemedicine and automated monitoring of stretcher-bound patients. All of that technology is coming in from the medical tech field, and that's being underpinned not necessarily by defense or even the medical field, it's by our civilian medical evacuation helicopter providers, people like CareFlight who provide some of our emergency response helicopters for our ambulance services."

The fifth point is where the quest for next generation autonomous systems fits into the evolution of the art of warfare.

This can be looked at in two different ways: one the specific defense geography of Australia and secondly, the strategic shift from the Middle Eastern land wars to operating in conflict with peer competitors.

This first revolves around shaping the distributed integratable force in which combat clusters can operate at the tactical edge with enough capability to achieve their tasks as allocated by mission command requirements. Distribution is about working multi-domain warfighting packages. Next generation autonomous systems can provide increased mass for each combat cluster notably with ISR payloads already on the way.

The second revolves around the geography of Australia. Given the importance of Western to Northern Australia to the first island chain of the Solomon Islands, there are a number of ways next generation autonomous systems can provide for capabilities throughout the distributed operational space.

For example, port security at a distance is a crucial requirement. Already, autonomous maritime USVs exist with the relevant ISR systems to provide significant inputs to meeting this mission.

As the ADF works through how best to build a defense grid over this region for its operations, it makes a great deal of sense to build in new autonomous systems as players in that defense grid. This solves a key problem which is where to add new capabilities without degrading extant capabilities, for as you build out a new approach to an operational area building in new platforms and systems can be done with realism in terms of delivering a desired combat capability, rather than just building prototypes or briefing slides, more likely to put your audience asleep than building capabilities which deter an adversary.

And finally, we discussed Triton. WGCDR Joyce has Triton in his portfolio, and I have visited Jax Navy several times as well as RAAF Base Edinburgh where the P-8s and Tritons will be operated from. The point can be made simply: This is a U.S. Navy led effort on manned-unmanned teaming NOW and lessons learned from such teaming clearly inform a way ahead for next generation autonomous systems.

In short, next generation autonomous systems are clearly on the way. As WGCDR Joyce underscored: "All of the services see robotic autonomous systems as a significant part of the road ahead. It's just that the services are getting after them differently."

THE APPENDIX

The Speakers and the Agenda

Program – Session 1

0800-0830	Registration, light breakfast and tea and coffee on arrival
0830-0835	Welcoming Remarks AIRMSHL Geoff Brown AO (Retd) Sir Richard Williams Foundation
0835	Introduction and MC WGCDR Keirin Joyce CSC Air Force Remotely Piloted Aircraft Systems
0835-0855	*Historical Perspectives* GPCAPT Jo Brick Australian Defence College
0855-0915	*Some Legal Aspects of Autonomous Systems* Professor Rob McLaughlin Australian National Centre for Oceans Resources and Security
0915-0935	*Trusted Autonomous Systems and Force Design* CDRE Michael Turner CSM and Bar, RAN Force Exploration
0935-0955	*Current Initiatives and Opportunities* Professor Jason Scholz Trusted Autonomous Systems Defence Cooperative Research Centre
0955-1015	*Navy Vision for Autonomous Systems* VADM Michael Noonan AO, RAN Chief of Navy

Program – Session 2

	Morning tea
1045-1105	*The RAAF Loyal Wingman and reviving Australian Aerospace Industry* Andrew Glynn Boeing Australia
1105-1125	*Countering Autonomous Systems* AVM Bill Henman AM (Retd) Raytheon Australia
1125-1145	*Building Enduring Sovereign Industry Capability'* Dr John Best Thales
1145-1205	*Autonomy and Logistics* COL David Beaumont Australian Army Research Centre
1205-1225	*Opportunities for Disruptive Innovation* Marcus Hellyer Australian Strategic Policy Institute
1225-1300	*Panel Discussion* Facilitated by WGCDR Keirin Joyce CSC

Program – Session 3

1300-1345	Lunch
1345-1400	*Investing in Autonomy for National Resilience – Not a Luxury but a Necessity* Dr Andrew Lucas Agent Oriented Software Group
1400-1420	*Autonomous Systems as an Enabler for Networked Operations* AVM Chris Deeble AM, CSC (Retd), Northrop Grumman Australia and Scott Winship via Zoom Northrop Grumman Corporation
1420-1440	*Developmental Requirements and Challenges* Dr Tony Lindsay Lockheed Martin
1440-1500	*Army Vision for Autonomous Systems* LTGEN Richard Burr AO, DSC, MVO Chief of Army
1500-1520	*Air Force Vision for Autonomous Systems* AIRMSHL Mel Hupfeld AO, DSC Chief of Air Force
1520-1530	Formal Close AIRMSHL Geoff Brown AO (Retd) Sir Richard Williams Foundation

The Future of Unmanned Systems

Arthur H. Barber III provided an insightful paper which provides, in effect, an introduction to the seminar and can be found on The Williams Foundation homepage.

That paper follows:

The next generation of military force design is moving rapidly toward increased use of vessels, vehicles, and aircraft that have no humans onboard. This change is driven by military necessity; large military platforms with humans onboard are increasingly expensive and increasingly at risk to adversary precision targeting and weapon systems. A wider distribution of force capability across more numerous, more risk-worthy, and less costly platforms is clearly an operational imperative of the future.

While referred to as “unmanned”, many of the systems in use today are more accurately characterized as “remotely operated” as human operators still remain directly involved in their control and sustainment. Emerging technologies are reducing the degree of this involvement, but many challenges remain to be dealt with in order for such systems to reach the full potential attributed to them by military visionaries.

Military platforms have typically brought together in one place a set of sensors and payloads that humans onboard directed toward military missions, whether conducting a sensor search for specific things, delivering logistics, or completing a full effects chain against an adversary. Human crews interpret data and provide tactical direction for these actions, and most such platforms are multi-mission.
Unmanned systems offer the possibility of disaggregating the functions needed to perform military missions across larger numbers of smaller, less individually expensive but more mission-specialized platforms, with human direction provided remotely.

The level of detail of this human direction determines the amount of networked connectivity that must be provided for the unmanned system. Connectivity, especially across ranges beyond direct line of sight, will be heavily contested by modern adversaries. Technologies that employ techniques of machine learning (ML) and artificial intelligence (AI) to reduce the amount of data that must be transported to support human direction and thereby lighten the demand on connectivity will be critical to the future warfighting potential of unmanned systems.

Military unmanned systems can be thought of as providing capability in three broad categories of missions: delivering sensors; delivering payloads; and conducting engagements. Each of these drives specific types of technical, operational, and doctrinal issues that must be addressed to achieve mission success.

Sensor Delivery

Today’s generation of unmanned sensor-carrying platforms generally stream sensor data back, sometimes non-real-time, to a place where humans interpret it to identify contacts of military interest. Doing this real-time requires large amounts of bandwidth that will be difficult to sustain against modern adversaries, particularly at ranges beyond line of sight or under the water. New developments in ML/AI are required to distill this sensor data onboard the vehicle down to highly trustworthy and concise contact reports that can be delivered promptly within limited bandwidth.

The specific requirements for doing this for military missions cannot solely rely on the ML/AI technologies that the commercial sector is developing for their purposes; the military’s requirements are different and the historical data needed to “teach” the ML/AI for wartime missions is generally not available today. This is by no means an easy or solved technical problem, but it is one where substantial developmental work is occurring.

Payload Delivery

Unmanned systems permit military payloads such as weapons or logistics, to be positioned and moved in a more widely distributed manner, and in smaller, more risk-worthy packages than would generally be possible with manned platforms. The end-state of actual delivery of these payloads – whether the firing of a weapon or the transfer of logistic items – still requires human action, as does periodic replenishment of the platform's energy supply and maintenance of its systems. Autonomous safe navigation of unmanned platforms in a complex, often ambiguous military operational space that may change rapidly in wartime from peacetime norms is a rapidly advancing technology.

Much work remains to be done to achieve the degree of reliable performance and endurance required for this unmanned mission to reach its full military potential. While unmanned systems are certainly more risk-worthy than manned platforms, they and their payloads are still valuable and sensitive and they will be targeted. Their susceptibility to adversary destruction, or to capture and exploitation, in peacetime or war, is also a key doctrinal concern.

Engagement

An often-stated vision for unmanned systems is employment for autonomous application of effects against an adversary, operating at decision speeds that are more rapid than that of humans, and thereby achieving operational dominance. The decision to apply lethal or irreversible effects, kinetic or otherwise, is one that under most conditions today requires a decision by an accountable human, at least in free-world militaries. This decision may be "man in the loop" with the human operator directly integrating data and applying judgement to make the decision, or it may be "man on the loop" with the human reviewing a machine proposal with the capability to reject it.

Either form of such "manned-unmanned teaming" can be reconciled with current legal and military doctrine, but there must be enough connectivity, information flow, and time for the human to exercise this role. The degree of trustworthy, transparent AI required to turn this decision over entirely to an unmanned system and thereby greatly accelerate tactical speed of action will require very significant technical development and doctrinal or policy changes, particularly for missions beyond immediate self-defense.

The development and fielding of unmanned military systems is proceeding rapidly at the technical level, often at rates that outpace the organizational processes for determining their appropriate integration into the military force. That is where the vision of the future encounters the reality of what these systems can actually do and are trusted to do today.

Today's systems largely still rely heavily on high-bandwidth long-distance connectivity that will not be assured against modern adversaries, or that in the case of undersea systems may not be achievable at all. With the exception of some air systems, today's unmanned systems also lack the mechanical and software reliability and endurance to sustain mission operations across a sufficient period of time and range of conditions to be tactically useful, particularly in the vast expanses of the Pacific theater.
Much technical work remains to be done in order to get unmanned systems to the level of capability needed for them to assume their envisioned role in the future military force.

Additional and accelerated development is required in four technical areas to deliver the full future operational promise of unmanned military systems a timeline that is needed to respond to the pressing threat challenges to which their use is an appropriate response:

- Sensor processing and fusion technology that permits unmanned systems to use their sensors to develop accurate, concise, and trustworthy track information in a timely manner and in the presence of adversary deception efforts, rather than streaming high bandwidth raw sensor data off board for remote interpretation and fusion

- Communications networks that can securely and reliably connect unmanned systems to the rest of the force and potentially among themselves to the degree needed for mission execution, at operationally significant ranges and relevant data transmission time latencies, and in the presence of adversary jamming efforts
- System reliability that permits unmanned systems, particularly those on and below the water or on the ground, to safely navigate and sustain their mission with high confidence for operationally significant periods of time without human intervention
- Energy storage and replenishment capabilities that permit an unmanned system to sustain its operations for operationally significant periods of time without returning to a vulnerable base.

Technical developments alone are insufficient, however; these must be accompanied by development of the new operational employment concepts and doctrine needed to employ these unmanned systems to best effect. By the time the technologies are in place that permit fielding unmanned systems in numbers that could deliver an effective operational capability in a mission area, the necessary changes in supporting structure, policy, and doctrine must be in place as well.

Exercises and experimentation with early prototypes must aggressively explore and resolve these types of issues before full-scale fielding of an unmanned element of the force. Key issues that must be addressed in parallel with technical developments include:

- Policy and doctrinal acceptance of the trustworthiness of AI/ML-informed track information from an unmanned system as a basis for a human operational decisions
- Doctrinal changes that employ distributed unmanned systems in new ways that leverage their capabilities to increase overall force effectiveness, and training of the whole force in that new doctrine
- Doctrinal resolution of how to deal with the risk of capture/exploitation of unmanned systems, particularly in peacetime
- Maintenance and logistic concepts that establish the supporting infrastructure for unmanned systems in places that maximize their operational availability without creating targeting vulnerabilities to an adversary
- Command and control concepts that establish the command structure and the physical locations from which operational control of each type of unmanned system will be exercised and the networks that will be used for this control.

Unmanned military systems are a rapidly-developing area of the future military force. A force that has capable unmanned systems and employs them effectively will have distinct operational advantages in future conflict. The difficult technical, doctrinal, and logistic challenges that must be addressed to bring this to fruition must be clearly recognized and addressed in parallel to fully deliver this result. The military that does this best and fastest across a wide range of missions will put itself in a position of great strategic advantage.

Arthur H. (Trip) Barber III is a retired U.S. Navy captain and civilian senior executive who was the Navy's chief analyst for 12 years. He is now the chief analyst at Systems Planning and Analysis, Inc.
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Sustaining Machines: Logistics and Autonomous Systems

By David Beaumont

The popular discussion on autonomy in warfare is constrained to either describing the advantages of introducing autonomous systems for 'dull, dirty and dangerous' work, or articulating the limitations of their use (including ethical limitations).

In terms of 'logistics', we can focus on how automation promises to distribute more things to more combatants more quickly, replaces forces in the field, or help us to be more productive and economical with our resources.

Automation offers military logisticians tremendous advantages and has to be a part of their future. The opportunities for automation in logistics are virtually limitless, only requiring technology and entrepreneurship to deliver a generational change to military technology. It becoming easier to find such opportunities given the vibrancy of the industry sector, and the enthusiasm robotics presently generates in defence circles. Rather than go through all of these opportunities, this article describes the capability that brings all of the pieces of an autonomous logistics system together – what we call the control network. This is a strategic capability which must be invested in.

Then I will discuss: What does the introduction of autonomous systems mean with respect to generating and deploying military forces? This is an important topic because to properly introduce autonomous systems into the military, we best be prepared for organisational change, cultural change and necessarily closer relationships between the military and industry.

In other words, I'm going to talk briefly on how we might make the capabilities we intend to develop practically useful and sustainable.

Automated and autonomy in logistics

The military use of autonomous systems conjures the vision of multi-domain technologies connected together in a mutually-supporting 'kill web'. Swarmed drones, larger UAS, submersibles and other capabilities operating automatically and nominally without human influence (maybe even interference).

Though the technology is revolutionary, the idea is not; the "kill web" is to combat operations what the logistics control network is to framework which sustains the operations. This network uses sensors to make decisions about what is moved where. As militaries introduce more and more autonomous systems into service, many of them to fulfill logistics tasks, the importance of this network cannot be understated.

We've had an automated logistics control network for decades. Logistics information systems – with all their benefits, liabilities and risks – have been essential to commercial and military logistics since the invention of computers. They have allowed the archetypal complex system – the commercial supply chain – to be analysed to excruciating detail. There is nothing stopping militaries becoming an 'Amazon' given the technology that is on offer; provided it is militarised and reflects the needs of fully deployable system that can function in a crisis.

Naturally, as armed forces explore the use of autonomous systems, they will also have to explore the use of automation to truly leverage the opportunities autonomy will deliver. Let's militarise the idea.

Effective logistics information systems enable these forces to more efficiently prioritise and allocate resources by leveraging sensor-based analytics, thereby creating additional capacity in the military supply chain and other logistics functions. When greater logistics capacity is found, this naturally means more options open up for the strategist, tactician or capability manager. Incorporate scalable, swarming, logistics UAS or autonomous convoys into this system and a remarkable level of efficiency might be possible.

The use of information-age technology has helped address what has been described as 'the logistics snowball' – the propensity of poorly planned and executed logistics to expand logistics requirements as more and more people, and more and more resources, are directed to problem solving. The opportunities on offer to us with future forms of autonomous systems are tremendous and will undoubtedly continue to be exploited.

But we must ensure that whatever logistics autonomous systems are introduced that they are introduced with a backbone control network that makes the whole effort worthwhile. Automated, not autonomous, logistics is probably where the best return of investment of the defence dollar lies.

Automated systems remove the guesswork out of logistics – militaries can get a truer sense of our capability and capacity at any given point in time. Vehicle 'health and usage monitoring systems' and other similar technologies are exemplars of this. They enable decisions about capabilities to be made at a faster tempo than ever. It's been a rocky journey with the systems – for example, the 'Autonomic Logistics Information System' for F-35 Joint Strike Fighter has received a significant upgrade to overcome highly-publicised problems – but this really is a new era of information management and problems are inevitable.

For these systems to offer the most to military logisticians, there is the issue of data management that we must eventually come to terms with – who owns it, when it can be used and for what reason – including ownership of the algorithms that may ultimately make decisions which were formerly the purview of military commanders.

Information, extrapolated into data, provided by these systems, is strategically vital. The complexity of military supply chains has expanded with globalisation, increased civilianisation and outsourcing of logistics capability, and with the sharing of capability across coalition partners. Automated logistics, appropriately secure, will help us garner where risks lie such that timely plans can be developed. Shortages could be better avoided. Costs could be better understood. Supply through multiple levels of producers and manufacturers can be accurately tracked thereby alerting the military to risks relating to the manufacture of capability.

Secondly, autonomous systems may have the computational power to predict and automatically react to ensure the right product is at the right place at the right time. This will assist in signalling industry as to where supply deficiencies lie, and can support mobilisation processes when strategic crises first appear.

It is important to be aware of the risks.

Cyber threats are persistently targeting global businesses, so Defence must prepare itself during the transformation of its logistics capability. In a 2018 testimony to the US Senate, the Commander of US Transportation Command General Darren McDew, highlighted the cyber threat to logistics as 'being the greatest threat to our military advantage.' Malicious state and non-state actors are already targeting vulnerable, largely unprotected, commercial systems linked in with barely protected military logistics systems. This threat was verified in the Defence Science Board 2019 report on 'Survivable Logistics'.

Why would a hostile target a hardened, highly classified decision-support and command and control network, when a soft underbelly is already presented to them?

Though there are threats to the automation of our military supply chains, the positives clearly outweigh the negatives. It is unequivocally the best solution to the logistics problem of our time – productivity. Logistics autonomy fundamentally gives armed forces greater capacity to do more with less, or better still, much more with the same. It simplifies something that would otherwise be highly manpower intensive.

But think of what can be done when an advanced predictive AI is aligned with a scalable autonomic distribution system? It can provide new vectors to deliver battlefield resources to the point at need, at a lower risk to human life. There are considerable financial advantages to Defence and Government if such capabilities are programmed and funded, and military advantages that might just contribute to the elimination of the large logistics footprint within an operational area.

The Logistics of Autonomy

How are forces that include autonomous systems generated and sustained? Militaries using autonomous weapons will, if we are optimistic about the technology, necessarily look very different in twenty, thirty years in the future. It is largely self-evident that bringing new technology into military organisations is challenging.

What isn't often acknowledged is how impactful this technology may be on the characteristics of the military organisation. The introduction of technology can have hidden consequences which are rarely apparent until the technology is in use.

New ways of doing business will be needed, organisations redesigned and policies created. Naturally, it's important that these outcomes are prepared for. Firstly, military logistics in war will be different – it is going to change in a way that hasn't been seen since the combustion engine was introduced. Motorisation, mechanisation, rocketry and flight have already elevated the importance of specialist mechanics, petroleum operations, munitions specialists and supply specialists. So too has the act of providing better materiel and training to each combatant – the battlefield has been 'thinned' with each able to bring greater firepower to bear on the enemy than the previous generation, but the logistics per unit cost of the combatant has also increased. Conventional military forces are not getting logistically 'lighter', and despite the desires of hopeful force designers, are unlikely to do so with automation.

The centre of gravity for military forces is inextricably moving from the battlefield and to the supply depots, bases, ports and defence infrastructure – the 'rear echelons' – as new technologies such as autonomous systems beckon. We've got to appreciate what this means in the context of opportunities, risks and vulnerabilities.

Secondly, the introduction of complex systems and machines will transform the way militaries will organise.

I wrote here, citing Chris Demchak, of the introduction of the M1A1 Abrams tank to the US Army forty years ago as an illustration of the problem. It's good analogy on the impact of technology on military logistics systems and organisations writ large. This was a tank designed to leverage technology and be less personnel-intensive, with a lower maintenance bill, simple to operate and decisive in combat. It was simple to operate, but proved difficult to repair and sustain. It could not be repaired without the OEM involved, and the technology often mystified even them. The US Army responded by procuring new testing equipment, and created new technical specialities to handle repair.

The level of technology required for the tank made the supply of parts for it challenging. Unexpected costs and the insufficiency of repair parts to support the tank ensured supply was handled with such scrutiny that an entire logistics bureaucracy was created. This generational change in equipment meant that US Army now has an incredibly effective tank with no real peer, but it was not an easy introduction into service.

Militaries will have to prepare for the same with the introduction of autonomous systems.

This will not be a venture without significant implications for the transformation of the militaries over coming decades.

It will not be a venture that can be rushed into without understanding the risks, and we must recognise that we're at the beginning of this challenge. This challenge will require Defence to experiment, discuss about and tinker with these truly revolutionary capabilities, but it must also consider new concepts and policies to better integrate these capabilities into the organisation.

Thirdly, the logistics liability for operating these systems must be understood.

Separating military robots and battlefield automation from the rest of the discussion, it's pretty clear that we're at the infancy of tactically useful systems that can be employed en masse.

At the moment, and especially in the Land Domain, many battlefield systems are ‘brittle’, not particularly adaptable and easily break down. This reflects the difficulty for machines that lack the maneuverability of a human being, or have difficulties operating in close proximity to them.

The situation is better for military aviation and in the maritime context. It will be some time yet before the ‘medic’ is replaced with the ‘mechanic’. But when they are, militaries will have to be respectful that the act will be transformational in the military workforce – especially with Army where this problem will be acute. It may even be aggravated by a human-machine ‘teaming’ approach where both forms of combatant are employed.

Perhaps we can combat the ‘less-positive’ effects of automation by focussing on the notion of disposable military robots. It’s tempting to think that robots can be abandoned when it is damaged or no longer in use; it appeals to our sense that there is a real possibility that humans can be removed from danger and replaced with something of lesser value. It’s patently a present day unreality save in very small-payload logistics operations. Until production lines run so large that costs are driven down, or newer technologies are found that dramatically lower costs, it will be inevitable that we treat autonomous systems with the same level of care we do any other form of exquisite technology. Nonetheless, it is likely that this problem will be overcome with time, technology and effort.

Fourthly, the link between the military and industry partners will necessarily be closer than ever. Larger logistics requirements do not always require larger military logistics organisations, but it does mean militaries need to be better at incorporating civilian resources into their operations. Military logistics always extends into the economy – more specifically the nation’s industrial base – and autonomy necessarily means that the integration of industry into the routine sustainment of new capabilities will remain important. It is quite clear that industry partners will have to continue to work closely, if not intimately, with armed forces to provide the technical support and expertise that is traditionally difficult for the military to generate independently. The workforce both generate is one that is shared irrespective of whether a uniform is worn or not. It is also clear that a conversation about how skills may be transferred into the military workforce if needed in a crisis must be had, or how autonomous systems might be sustained and repaired in conflict zone.

This leads onto the final topic I wanted to cover on the logistics of autonomy. It is not lost on most readers that there is a tremendous opportunity for defence industry to step into an electronics industry gap is only beginning to be filled. If we are to embrace the use of autonomy in militaries such as the Australian Defence Force as a credible alternative to the human combatant, it will be highly advantageous for the military to have a national industry behind it. A dependency on foreign components and construction can become a strategic risk – especially as global supply chains are contested or limited resources shared.

I suspect that electronics and componentry join ammunition and fuel as a marker of strategic resilience in due course. In the meantime, all will need to be careful about accelerating into autonomy else we embark upon a costly sham with unviable capabilities in combat. Perhaps this necessitates us having a conversation about innovations and their identification as a matter of strategic value and a target of regulation.

Most innovations in autonomic systems will come from the private sector, and in many cases, will be available to the highest bidder. This could even discount any investments that Governments may make into the sector. A pessimistic view of the future suggests we need preserve whatever advantage we can, and – as a nation – we might have to balance our commercial and strategic interests. Australia’s stake in autonomous systems development is an important one, with strategic implications. With autonomy firmly on the horizon for the ADF and other advanced militaries, it seems clear that we must initiate this discussion now.

This article, I admit, is a smorgasbord of ideas.

Logistics is first and foremost about practicality, and it is important to ensure autonomous systems that are introduced do what is intended. There’s good reason for an investment in autonomous systems in the short term; they certainly offer a way to overcome some of the structural shortcomings faced by the military in terms of 'mass' and an ability to operate as efficiently and effectively as we need to be.

But we must not race to failure. Militaries cannot afford to let autonomous systems become a capability 'drag' by not being diligent.

Automation will create new options at all levels of war, improve the capacity of a defence force pressured by its relative size, and give us new opportunities to exploit. The technology behind automation is an area where Australia can generate a strategic advantage if it chooses to; we have a high standard of education and a long track-record of innovation as a nation.

Western militaries, in general, prepared for change and actively seeking partners to overcome many of the challenges, and take advantage of new opportunities, that have been raised here.

We all know how rapidly the technology around automation is evolving. The all work on overcoming the logistics limitations of autonomy the better. Technical and conceptual discovery must occur at pace. This way the potential of the technology will be realised, rather capabilities or systems that are too exquisite to be practically employable, unsustainable, or offer little in being part of a strategic offset, result.

This is an enduring problem with introducing new technology into defence forces in a time of relative peace, where there is always a temptation to make expedient decision and mortgage the future as a consequence.

This was adapted from Col. Beaumont's presentation at the Williams Foundation Seminar on Next Generation Autonomous Systems on **April 8, 2021.**

The Australian Approach to Developing and Deploying Remotes Systems in the Maritime Environment: The Perspective of Cmdr. Paul Hornsby

By Robbin Laird

October 12, 2019

Recently, I attended the Chief of the Royal Australian Navy's Seapower conference being held in Sydney from October 8th through the 10th, 2019.

One of the sessions which I attended was a presentation by Cmdr. Paul Hornsby, Royal Australian Navy lead on autonomous warfare systems.

The presentation provided an overview on how the Australian Navy is addressing the development and evolution of remote systems within the fleet.

During my visits over the past five years in Australia and my time with The Williams Foundation, I have been impressed with the ADF and its efforts to build a transformed force.

The transformation process has been identified as building a fifth-generation force.

And within that effort, the significant modernization envisaged for the Australian Navy is focused on shaping a transformed maritime force as well.

As former Chief of Navy, Vice Admiral (Retired) Barrett put it in our interview earlier this year: "We are not building an interoperable navy; we are building an integrated force for the Australian Defence Force."

The kill web approach was clearly what he is working from when he discusses force modernization for the Navy.

In this process of force transformation, the ADF is committed to a wide range of innovative roll outs to experiment in the evolution of its fifth-generation con-ops.

This is why for a much larger force like the United States possesses, the Australians in their approach represent not just innovation for themselves but for the U.S. and other Australian allies.

Nowhere is this more evident than in the domain of unmanned maritime systems.

As Hornsby put it in his presentation: “We have no choice but to be leaders in this area.”

He underscored that the significant operational area which Australian forces need to patrol coupled with limited numbers of maritime platforms and manpower limits meant that the building, operating and integration of maritime remote systems in the fleet was an operational necessity for the Royal Australian Navy.

“We could not get enough help from remote systems and artificial intelligence.”

He argued that there was a cross-societal engagement with remote systems in Australia which the Navy could leverage as well.

He noted that Australia has been involved in allied exercises across the board in the remote systems area.

He laid out through the various exercises in the UK, Australia and elsewhere that his team has been fully engaged in cross learning with allies, and to do so in order to harvest the best and leave the rest.

He made a case for why Australia is a very important area for allies to work with the Aussies on remote innovations.

The conditions in Australia are challenging and paraphrasing Frank Sinatra: “If you can make it here, you can make it anywhere.”

I would argue that the current challenge facing the US and allies shaping an integrated distributed force is being able to make decisions at the tactical edge. Certainly, the introduction of the F-35 is providing a forcing function with this regard.

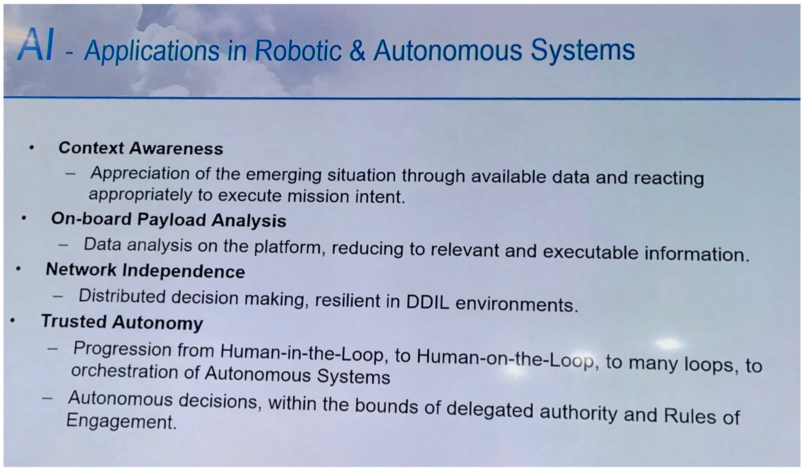
As allied militaries work their approaches toward shaping an integrated distributed force, and once they have forged approaches to make decisions at the tactical edge, they are then able to leverage what artificial intelligence operating in a network of remote systems, such as maritime remotes, can deliver to the combat force.

In other words, learning how to make decisions at the tactical edge with the fifth-generation force will allow for the next wave of innovation which AI-enabled remote systems decision making.

Cmdr. Hornsby underscored a number of key contributions of AI to the build out of a remote system distributed force.

The following graphic highlights the key aspects which he highlighted.

Key points are reaching a stage where the remotes can work with one another, underwater and above water, to provide SA to the battle commander; and to shape ways for the distributed system to assist and make decisions in something which really as way beyond the classic OODA loop.



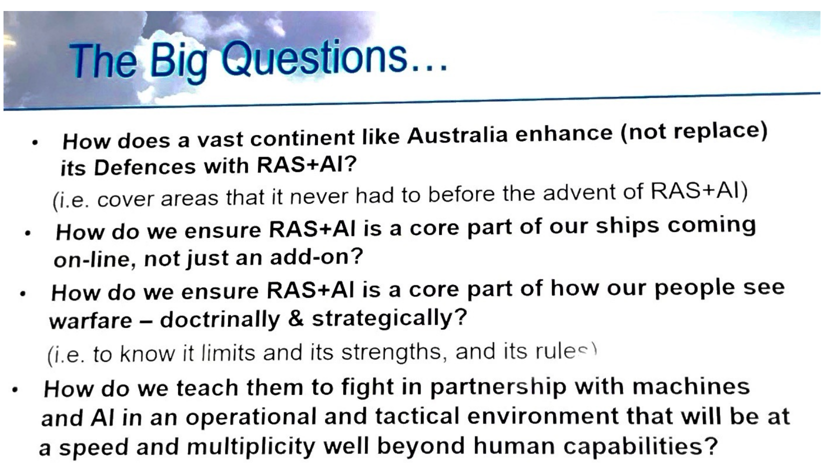
When the machines are working OO and notably with AI then the focus is upon how to DA.

And even more to the point, humans and machines need to work the decision-making loop together and this requires significant learning on the human side for sure.

As he concluded his presentation, he framed a number of key questions which he argued needed to be addressed and ways ahead found to answer them.

It is often the case, that change is really about changing the nature of the questions which need to be answered, rather than finding new answers to older questions.

The following graphic lays out the core questions which he posed:



I would highlight one of those questions for a further comment– the need to design new combat ships from the outset to have the capabilities to operate with remotes.

This means that new platforms moving forward need to have data processing capabilities, personnel able to operate SA systems, an ability to include relevant remote platforms onboard as well as a range of platform payloads, and technicians onboard able to deliver sustainment to systems operating at a distance and over relatively long operational times.

In short, for Cmdr. Hornsby the future is now. And I would add my own judgement – it is crucial to get some of these systems at sea in the operational force for these platforms and payloads will be transformed over time by operational input even more than R and D done by researchers alone.

Shaping an Australian Navy Approach to Maritime Remotes, Artificial Intelligence and Combat Grids

By Robbin Laird

February 3, 2020

During my visit to Australia last October, I had a chance to talk to a number of people about the evolving approach in Australia to maritime remotes and their evolving role within the "fifth generation" warfare approach or what I refer to as building a distributed integratable force or an integrated distributed force.

Towards the end of my stay, I had a chance to discuss with the key presenter on this topic at the Seapower Conference held in Sydney in early October, Commander Paul Hornsby, the Royal Australian Navy lead on maritime remotes.

We discussed a number of issues, but I am going to focus on where maritime remotes fit within the evolving strategic thinking of the Royal Australian Navy and its contribution to the ADF.

The broad point is that Australia is focusing on robotics and artificial intelligence more generally in its economy, with clear opportunities for innovation to flow between the civil and military sectors. Australia is a large island continent with a relatively small population. For both economic and defense reasons, Australia needs to extend the capabilities of its skilled manpower with robotic and AI capabilities. For the Navy, this means shaping a much large "fleet" in terms of a significant web of maritime remotes working interactively with the various manned assets operating in an area of interest.

Commander Hornsby highlighted the 2018 Australian Robotics Roadmap as an indicator of the Australian approach to cross-leveraging robotic systems and AI. As the report noted. "Robotics can be the force multiplier needed to augment Australia's highly valued human workforce and to enable persistent, wide-area operations in air, land, sea, subsurface, space and cyber domains."

A second broad point is that Australia is working closely with core allies to forge a common R and D pool and to cross-learn from one another with regard to the operation of maritime remotes and their ability to deliver capabilities to the operational forces.

An example of the cross-learning and collaborative approach was Autonomous Warrior 2018. The exercise was a "milestone in allied cooperation," according to Lt. Andrew Herring, in an article published on November 24, 2018.

When more than 50 autonomous technologies and over 500 scientists, technicians and support staff came together for AUTONOMOUS WARRIOR 2018 (AW18) in Jervis Bay, ACT, it marked the culmination of four years' collaboration between the militaries, defence scientists and defence industries of five nations.

Today, Navy's Deputy Director Mine Warfare Diving and Special Ops Capability, Commander Paul Hornsby, and Defence Science and Technology's (DST) Trusted Autonomous Systems Program Leader, Professor Jason Scholz, are exploring autonomous technologies with US Air Force Research Lab's Senior Engineering Research Manager, Dr Mark Draper and Dr Philip Smith from the UK's Defence Science and Technology Laboratory.

The four, with their respective organisations, are collaborating under the Five Eyes' Technical Cooperation Program (TTCP), which shares information and ideas among defence scientists from Australia, UK, USA, Canada and New Zealand, pursuing strategic challenges in priority areas.

Among them is TTCP's Autonomy Strategic Challenge, which aims to integrate autonomous technologies to operate together in different environments.

AUTONOMOUS WARRIOR 2018 includes the Strategic Challenge's fifth and final scientific trial – 'Wizard of Aus' – a software co-development program aimed at managing autonomous vehicles from a shared command and control system that integrates with combat systems used by Five Eyes nations.

US Air Force Research Lab's Dr Mark Draper summarises AW18's ambitious objective. "What we are trying to achieve here is force multiplication and interoperability, where multiple unmanned systems from different countries—in the air, on the ground and on the surface of the water or even underwater—would all be controlled and managed by one person sitting at one control station."

Two systems together

To achieve this, two systems have come together: 'AIM' and 'MAPLE'.

'Allied IMPACT', known as AIM, combines best of breed technologies from Australia, United Kingdom, United States and Canada.

"We've brought these technologies together and integrated them into one control station and we are testing its effectiveness in reasonable and realistic military scenarios," Dr Draper said.

Australia has led development of three of AIM's eight modules: the Recommender, which uses artificial intelligence to analyse information and recommend actions to commanders; the Narrative, which automatically generates multimedia briefings about emerging operational situations; and DARRT, which enables real time test and evaluation of autonomous systems.

The Maritime Autonomous Platform Exploitation (MAPLE) system is a UK-led project providing the information architecture required to integrate a diverse mix of live unmanned systems into a common operating picture that is fed into the AIM Command and Control Station.

"The sort of software co-development we are doing here is not usually done," UK Defence Scientist Dr Philip Smith said.

"The evaluation team is using real time data logging to evaluate system performance, apply lessons learned and improve the software.

"This is also giving us detailed diagnostics to determine where to focus effort for future development," he said.

Revolutionary potential

DST's Professor Jason Scholz is optimistic about the potential for these technologies beyond AW18.

"This activity has demonstrated what can be achieved when a spirit of cooperation, understanding and support exists between military personnel, scientists, engineers and industry.

"Systems became more reliable as the exercise progressed with improvements made daily.

"These highly disruptive technologies can potentially revolutionise how armed forces operate. The sort of cooperation we've seen at AW18 is vital for bringing these technologies into service.

"It would be interesting to run a similar activity with these rapidly evolving technologies in two or three years," Professor Scholz said.

Lasting impact

Commander Hornsby, who has been the ADF lead for AW18 and is developing Navy's autonomous systems strategy, says the activity has raised awareness among Australia's Defence Force and defence industry.

"The nearly 1000 visitors to AW18 gained fresh insights into the technology's current state of development and its potential to enhance capability.

"As a huge continent occupied by a relatively small population with a mid-sized defence force by world standards, the force multiplier effect of autonomous systems is vital, which is why Australia is a leading developer.

The evaluations done at AW18 are also important internationally.

"The world is watching AW18 closely because Australia offers the most challenging operating conditions for unmanned technologies. If they can make it here, they can make it anywhere," Commander Hornsby said.

Autonomous Warrior 2018 was a major demonstration and evaluation of the potential of robotic, autonomous and uninhabited systems, in support of Defence operations in coastal environments. It combined a dynamic exhibition, trials and exercising of in-service systems.

Australian industry contributed semi-autonomous vehicles for use in AW18 and developed data interfaces to enable control by Five Eyes systems. Contributing companies included Bluezone Group, Ocius, Defendtex, Australian Centre for Field Robotics, Silverton and Northrop Grumman. Vehicles were also contributed by Australian, NZ, US and UK government agencies.

In our discussion, Commander Hornsby noted that collaborative R and D and shared experiences was a key element of the Australian approach, but that Australia had unique operating conditions in the waters off of Australia, and systems that might work in other waters would not necessarily be successful in the much more challenging waters to be found in Northern and Western Australia, areas where the deployment of maritime remotes is a priority.

But one must remember that the maritime remote effort is a question of payloads and platforms. Not simply building platforms. Rear Admiral Mark Darrah, US Navy, made a comment about unmanned air systems which is equally applicable to maritime remotes: "Many view UAS as a capability when in fact it should be viewed as a means of employing payloads to achieve particular capabilities."[1]

His approach to maritime remotes is very much in the character of looking at different platforms, in terms of speed, range, endurance, and other performance parameters, measured up against the kind of payload these various platforms might be able to carry.

Calculations, of the payload/platform pairing and their potential impacts then needed to be measured up against the kind of mission which they are capable of performing. And in this sense, the matching of the payload/platform dyad to the mission or task, suggests prioritization for the Navy and the ADF in terms of putting in to operation the particular capability.

This also means that different allied navies might well have different views of their priority requirements, which could lead to very different timelines with regard to deployment of particular maritime remotes.

And if the sharing approach prevails, this could well provide the allied nations to provide cross-cutting capabilities when deployed together or provide acquisition and export opportunities for those allies with one another.

Commander Hornsby breaks out the missions for AUV and UUV employment in the following manner:

Home & Away operations…

- ***Break Out (Around own critical / sensitive infrastructure – High end UUVs) •Break In (Deployed / Amphib – Low end AUVs / single shot / disposable)***
- ***Block Out (Autonomous Maritime Asset Protection / Robot UUVs / CIED)***
- ***Block In (High end AUVs – Sub Launch / XLUUVs / Mining / Intervention)***
- ***Surveillance (Persistent AUVs for surveillance / attribution – wave gliders***
- ***Servicing (Large UUVs for industrial off-shore tasks – in water docking)***

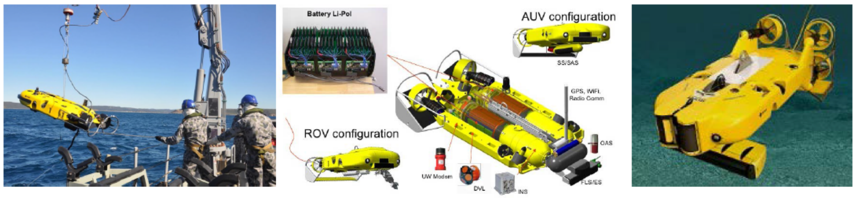
Pending combination, provides: Deterrence, Sea Control, Sea Denial, Power Projection or Force Protection

What this means is that different payload/platform combinations can work these different missions more or less effectively. And quite obviously, in working the concepts of operations for each mission or task which will include maritime remotes needs to shape an approach where their capabilities are properly included in that approach.

And in a 2016 briefing by Hornsby."[2], he highlighted this point as follows:

Break Out

Key features:
- Operate in stronger currents / greater depths
- Continuous operations / real time feed
- Hunt and dispose with one vehicle
- Reconfigurable
- Manipulation arms
- Recoverable charges
- ROV and AUV mode



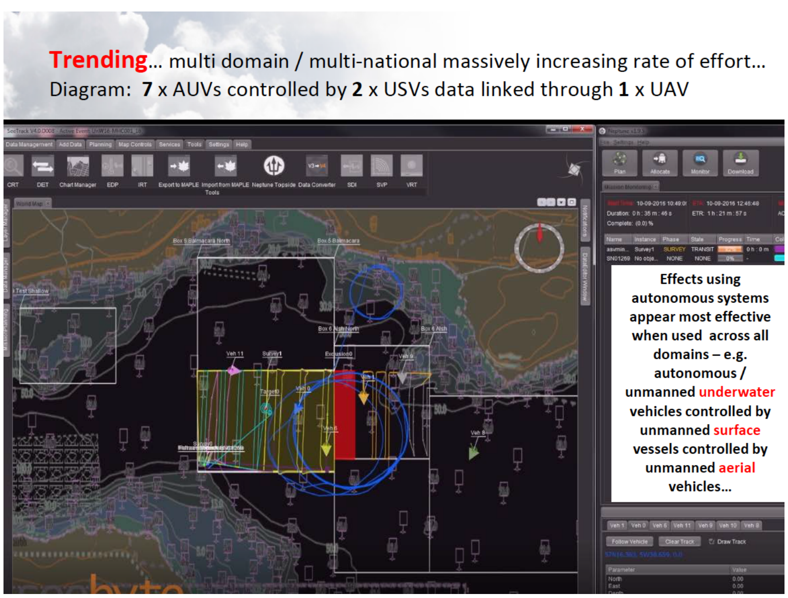
Break In

Key features:
- Clandestine
- Unmanned Surface Vessel (or Helo) launched
- Less risk if lost, captured or destroyed

But importantly, maritime remotes should not be looked at in isolation of the operation of the distributed force and how integratable data can be accumulated and communicated to allow for C2 which can shape effective concepts of operations.

This means that how maritime remotes are worked as an interactive grid is a key part of shaping an effective way ahead. And this allows for creative mix and matching of remotes with manned assets and the shaping of decision making at the tactical edge. Remotes and AI capabilities are not ends in of themselves; but are key parts of the reshaping of the C2/ISR capabilities which are reshaping the concepts of operations of the combat force.

In that 2016 briefing, Commander Hornsby provided an example of the kind of grid which maritime remotes enable:



To use an example in the European context, as the fourth battle of the Atlantic shapes up, if the allies can work cross-cutting maritime remote payload/platform capabilities and can operate those in the waters which the Russians intend to use to conduct their operations against NATO, then a new grid could be created which would have significant ISR data which could be communicated through UUV and USV grids to various parts of the 21st century integrated distributed combat force.

Such an approach is clearly crucial for Australia as it pushes out its defense perimeter but needs to enhance maritime security and defense of its ports and adjacent waters. And that defense will highlight a growing role for maritime remotes.

As Robert Slaven of L3Harris Technologies, a former member of the Royal Australian Navy, has put it:

"The remotes can be distributed throughout the area of interest and be there significantly in advance of when we have to create a kinetic effect. In fact, they could be operating months or years in advance of shaping the decision of what kind of kinetic effect we would need in a crisis situation.

"We need to learn how to work the machines to shape our understanding of the battlespace and to shape the kind of C2 which could direct the kind of kinetic or non-kinetic effect we are trying to achieve."[3]

The U.S. Navy Prepares the Way for Unmanned Surface Vessels

February 18, 2021

By LCDR (Retired) Jack Rowley

One of the most rapidly growing areas of innovative technology adoption involves unmanned systems. The U.S. military's use of these systems is not only changing the face of modern warfare but is also altering the process of decision-making in combat operations. These systems are evolving rapidly to deliver enhanced capability to the warfighter and seemed poised to deliver the next "revolution in military affairs."

The Department of Defense has evolved a comprehensive Unmanned Systems Integrated Roadmap that forecasts the evolution of military unmanned systems over the next quarter-century. Concurrently, funding for unmanned systems is predicted to rise year-over-year for the foreseeable future. Indeed, as the DoD has rolled out a "Third Offset Strategy" to evolve new operational concepts and technologies to deal with emerging peer competitors, unmanned systems have emerged as key—even critical—components of that strategy.

The U.S. Navy has a rich history of UxS development. By the turn of the century, the technology to control unmanned systems had finally matured to the point that the U.S. Navy believed it could successfully field unmanned systems in all domains—air, surface, and subsurface—to meet a wide variety of operational needs. The Chief of Naval Operations Strategic Studies Group (CNO SSG) was tasked to attempt to determine the feasibility of introducing unmanned systems into the Navy inventory.

The SSG recommended that the Navy move "full speed ahead" with unmanned systems.

The U.S. Navy's commitment to—and dependence on—unmanned systems is also seen in the Navy's official Force Structure Assessment, as well as in a series of "Future Fleet Architecture Studies." In each of these studies: one by the Chief of Naval Operations Staff, one by the MITRE Corporation, and one by the Center for Strategic and Budgetary Assessments, the proposed Navy future fleet architecture had large numbers of air, surface, and subsurface unmanned systems as part of the Navy force structure.

Most recently, in his FRAGO 01/2019 order, the Chief of Naval Operations, Admiral Michael Gilday, reemphasized the Navy's commitment to the tenets of A Design for Maintaining Maritime Superiority 2.0, and especially the plan for a future fleet with substantial numbers of unmanned systems. Indeed, the U.S. Navy is planning for a considerable investment in unmanned systems—especially unmanned surface systems.

Recently, the Navy established a "Surface Development Squadron," to experiment with unmanned surface vehicles. This new squadron has the mandate to accelerate the integration of unmanned surface systems into the Navy Fleet. It is important that this squadron turn the U.S. Navy's commitment to buy large numbers of USVs into operational concepts for specific missions that these vessels should accomplish.

While the Navy will buy substantial numbers of large, medium and small USVs, it has yet to evolve detailed plans of how these platforms might be used together to accomplish a variety of naval missions.

Additionally, the Navy would be well-served of moving away from "one-of" USVs for singular missions and explore the utility of investing in families of similar USVs to capitalize on putting together mutually compatible hull, mechanical and electrical (HME) attributes and systems.

Shaping a Way Ahead

In his best-selling book, *War Made New*, military historian Max Boot notes, "My view is that technology sets the parameters of the possible; it creates the potential for a military revolution."[1] He supports his thesis with historical examples to show how technological-driven "Revolutions in Military Affairs" have transformed warfare and altered the course of history.

The U.S. military has embraced a wave of technological change that has constituted a true revolution in the way that war is waged. As the pace of global technological change has accelerated, the United States has been especially adept at inserting new technology to pace the threat. As Bruce Berkowitz points out in *The New Face of War*:

"Wartime experience suggests that the right technology, used intelligently, makes sheer numbers irrelevant. The tipping point was the Gulf War in 1991. When the war was over, the United States and its coalition partners had lost just 240 people. Iraq suffered about 10,000 battle deaths, although no one will ever really be sure. The difference was that the Americans could see at night, drive through the featureless desert without getting lost, and put a single smart bomb on target with a 90 percent probability."[2]

While both books cited are over a decade old, what they say about technology remains on point regarding the ways that the U.S. military has embraced new technologies. Today one of the most rapidly growing areas of innovative technology adoption by the U.S. military involves unmanned systems. In the past several decades, the U.S. military's use of unmanned aerial vehicles (UAVs) has increased from only a handful to more than 10,000, while the use of unmanned ground vehicles (UGVs) has exploded from zero to more than 12,000.

The use of unmanned surface vehicles (USVs) and unmanned underwater vehicles (UUVs) is also growing, as USVs and UUVs are proving to be increasingly useful for a wide array of military applications. The exploding use of military unmanned systems (UxS) is already creating strategic, operational, and tactical possibilities that did not exist a decade ago.

These systems have been used extensively in the conflicts in Iraq and Afghanistan, and will continue to be equally relevant—if not more so—as the United States' strategic focus shifts toward the Indo-Asia-Pacific region and the high-end warfare this strategy requires. While these unmanned systems are of enormous value today and are evolving to deliver better capabilities to the warfighter, it is their promise for the future that causes the most excitement. As the U.S. military buys more and more unmanned systems, it is important to devise concrete plans for the use of these systems.

Planning for Military Autonomous Systems

At the highest levels of U.S. policy and strategy documents, unmanned systems are featured as an important part of the way the Joint Force will fight in the future. The most recent Quadrennial Defense Review (QDR) notes, "Continuing a trend that began in the late 1990s, U.S. forces will increase the use and integration of unmanned systems." Elsewhere in the QDR, unmanned systems are identified as: "Maintaining our ability to project power." Importantly, the QDR highlights unmanned systems as a key part of the DoD's commitment to innovation and adaptation.[3]

The U.S. Department of Defense's vision for unmanned systems is to integrate these systems into the Joint Force. Because unmanned systems are used by all the military services, the Department of Defense publishes a roadmap to provide an overarching vision for the military's use of unmanned systems. An article published in Inside the Navy soon after the new roadmap's release noted, "The Defense Department's new 30-year unmanned systems plan—the first update of the roadmap in four years—aims to chart a three-decade guide for the rapidly developing field of unmanned systems technology."[4]

As the QDR and Unmanned Systems Integrated Roadmap both note, unmanned systems are especially important assets in those areas where the U.S. military faces a peer competitor with robust defenses. The Joint Operational Access Concept identifies, "Unmanned systems, which could loiter to provide intelligence collection or fires in the objective area," as a key capability that is especially valuable in areas where an adversary has substantial defenses that can limit access of U.S. and coalition forces.[5]

And unmanned systems are a key component in executing the United States AirSea Battle Concept (now re-branded as the Joint Concept for Access and Maneuver in the Global Commons, or JAM-GC) in high threat areas such as the Western Pacific, where adversary defensive systems pose an unacceptably high risk to manned aircraft and surface platforms.[6]

The U.S. Navy Shapes a Way Ahead for Unmanned Systems

The U.S. Navy has a rich history of UxS development. During the early years of the last century, the Navy and the Army worked together to attempt to develop unmanned aerial torpedoes. However, this was a bridge-too-far given the state of technology during those years, and the project was ultimately abandoned. Other attempts to introduce unmanned systems into the Navy and Marine Corps occurred in fits and starts throughout the first half of the last century, but these met with limited success.

By the turn of the century, the technology to control unmanned systems had finally matured to the point that the U.S. Navy believed it could successfully field unmanned systems in all domains—air, surface, and subsurface—to meet a wide variety of operational needs. As with many disruptive and innovative ideas, the Chief of Naval Operations Strategic Studies Group (CNO SSG) was tasked to attempt to determine the feasibility of introducing unmanned systems into the Navy inventory.

The Navy's leadership is committed to unmanned systems. The importance of unmanned systems to the U.S. Navy's future has been highlighted in a series of documents, ranging from the revised *A Cooperative Strategy for 21st Century Seapower, to A Design for Maintaining Maritime Superiority*, to a Chief of Naval Operations *The Future Navy* white paper. The latter document presents a compelling case for the rapid integration of unmanned systems into the Navy fleet, noting, in part:

"There is no question that unmanned systems must also be an integral part of the future fleet. The advantages such systems offer are even greater when they incorporate autonomy and machine learning…Shifting more heavily to unmanned surface, undersea, and aircraft will help us to further drive down unit costs."[7]

The U.S. Navy's commitment to—and dependence on—unmanned systems is also seen in the Navy's official Force Structure Assessment, as well as in a series of "Future Fleet Architecture Studies."[8] Indeed, these reports highlight the fact that the attributes that unmanned systems can bring to the U.S. Navy fleet circa 2030 and beyond have the potential to be truly transformational.

More recently, the Chief of Naval Operations issued an update to *A Design for Maintaining Maritime Superiority 2.0*. Issued just two years after the first version of this document, Design 2.0 was issued for two primary reasons: to align with the recently issued National Security Strategy and National Defense Strategy, as well as to address the rapid technological changes that the Navy must embrace.

In his FRAGO 01/2019 order, Chief of Naval Operations, Admiral Michael Gilday, reemphasized the Navy's commitment to tenets of Design 2.0, and especially the plan for a future fleet with substantial numbers of unmanned systems.[9] Most recently, Advantage at Sea, America's new maritime strategy, continues the drumbeat regarding the importance of unmanned systems to the Sea Services.[10]

The U.S. Navy is planning for a substantial investment in unmanned systems—especially unmanned surface systems. For example, the Navy established a "Surface Development Squadron," to experiment with unmanned ships.[11] Future development ideas call for a "Ghost Fleet" of autonomous unmanned surface ships that could operate against an enemy force without putting Sailors in harm's way.[12] And it should come as no surprise that Congress is increasingly interested in the Navy's progress on unmanned surface vehicles, as witnessed by an increasing number of Congressional Research Service reports on USVs.[13]

NAVSEA has expressed its intention to reach an ambitious future of a fleet populated with scores—even hundreds—of unmanned vehicles, one of three key goals was to, "Integrate USVs with manned host platforms, which control the USVs from a distance.[14] The Navy announced its intention to spend $2.7B into researching and buying ten large unmanned surface ships over the next five years as part of an overall plan to buy 232 unmanned surface, underwater and aerial vehicles of all sizes over the next five years.[15]

In remarks during 2019 U.S. Navy League SeaAirSpace Symposium, the Navy's Deputy Chief of Naval Operations for Warfare Systems, Rear Admiral William Merz, confirmed this commitment unmanned systems when he noted, "Every study directed or initiated from within has told us we have to move out on these [unmanned surface vehicles] capabilities…Our commitment in our last budget to the tune of almost $3 billion in just unmanned surface vessels should be enough to signal to industry we're very serious about this."[16]

The U.S. Navy's commitment to unmanned systems is unlikely to wane as increasingly, these platforms continue to prove their utility in performing much of the dull, dirty and dangerous work that the Navy previously assigned to manned platforms."[17]

The Bridge to the Navy-after-Next

As the U.S. Navy continues to operate at high operating tempo in order to meet its global commitments, it is concurrently planning for "The Navy after Next." This Navy will be key to protecting the security and prosperity of the nation throughout the remainder of the century. The shape of this Navy is already evolving as ships currently in service are having their service lives extended, more of current classes of ships are being built, and as new ships are being planned.

The importance of unmanned systems to increasing the combat power of Navy fleet has been well-documented in the aforementioned "Future Fleet Architecture Studies" as well as the Naval Research and Development: A Framework for Accelerating to the Navy and Marine Corps after Next.[18]
The Naval Research Enterprise Addendum to the Naval Research and Development Framework drills down to technology areas, and then to specific technologies that will enable the Navy and Marine Corps to field decisive capabilities and dominate the future littorals in a high-end fight. Unmanned surface vehicles and unmanned underwater vehicles are called out as disruptive technologies that can provide leap-ahead capabilities for the Navy.[19]

The Naval Sea Systems Command, as well as the Navy laboratories that provide the technical expertise for the development of many unmanned surface and subsurface unmanned systems, have been accelerating the development of these USVs and UUVs. The Navy has partnered with industry to develop, field and test a family of USVs and UUVs such as the Medium Displacement Unmanned Surface Vehicle (Sea Hunter), MANTAS next generation unmanned vessels, the Large Displacement Unmanned Underwater Vehicle ("LDUUV") and others.

Indeed, this initial prototype testing has been so successful that the Department of the Navy has begun to provide increased support for USVs and UUVs, and has established program guidance for many of these systems of importance to the Navy and Marine Corps. This programmatic commitment is reflected in the Navy Program Guide as well as in the Marine Corps Concepts and Programs document. Both show a commitment to a variety of unmanned systems programs.[20]

Speaking at the January 2018 Surface Navy Association Symposium, the Navy's PMS-406 Program Manager, Captain Jon Rucker, spoke of the bright future for unmanned maritime systems, noting, "We have been given special authorities to do accelerated acquisitions." Captain Rucker concluded his remarks by explaining how the Navy will insert unmanned maritime systems into the fleet:

"As the technology is ready, we will insert it into the systems we're developing. In every system I show you, whether it's an unmanned surface vessel or unmanned undersea vessel, we are ensuring that we develop that modularity and have the interfaces, so as technology is ready, we can insert it into the production line—not break the production line—and ensure we stay on track to deliver that capability."[21]

The key technical phrase from Captain Rucker focused on "developing that modularity" thereby delivering new capabilities "without impact" on the production line. Subsequently, during the 2019 Surface Navy Association Symposium, the current Naval Sea Systems Command Program Manager for Unmanned Maritime Systems, Captain Peter Small, explained how NAVSEA's USV Systems Vision focused on "Enhanced, Efficient Capabilities" for large, medium, small and extra small, unmanned surface vehicles, and listed specific USVs to be fielded in near, near-to-mid, and mid-to-far timeframes.
The briefing slides presented in that symposium have been replicated in various publications such as the aforementioned Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress.[22]

Later that same year, at the U.S. Navy League SeaAirSpace Symposium, Captain Small, noted that, "We will bring in Navy program of record weapons systems to incorporate into commercially-derived modular craft."[23] The use of the phrases "modular craft" along with "commercially-derived" clearly indicate both the need and desire for the Navy to transition currently commercially-available unmanned craft, where a single USV platform can meet multiple missions through the use of "mission modularity" modifications to meet the needs of each of the specific mission-related sensors and weapons systems
This represents a technical challenge that commercial industry is not only ready, but eager, to meet.

But how to get there?

With this look at the commitment to unmanned systems, it is worth spending a bit of time understanding the missions the Navy and Marine Corps have planned for unmanned maritime systems, specifically, unmanned surface vehicles. Operating as they do at the air-water interface on the surface of the oceans, unmanned surface vehicles not only have their own discrete—and growing—list of current and future naval missions, but they also provide the connective tissue between aerial unmanned vehicles and subsurface unmanned vehicles as well as their manned counterparts.[24]

Like all unmanned systems, unmanned surface vehicles are critical assets in all scenarios across the spectrum of conflict and become more useful against high-end adversaries. Unmanned surface vehicles enable warfighters to gain access to areas where the risk to manned platforms is unacceptably high due to a plethora of enemy systems designed to deny access: from integrated air defense systems, to surface ships and submarines, to long-range ballistic and cruise missiles, to a wide range of other systems.

These unmanned surface vehicles can provide greater range and persistence on station, leading to enhanced situational awareness of an objective area. Indeed, in a high-end fight, unmanned surface vehicles can be viewed as expendable assets once they perform their mission.

Unmanned surface vehicles are especially adept at conducting the intelligence, surveillance, and reconnaissance (ISR) mission, and are typically better suited for this mission than their unmanned aerial vehicle counterparts for a number of reasons, particularly their ability to remain undetected by enemy sensors, as well as their dwell time on station. By performing this near-shore intelligence preparation of the battlespace (IPB), unmanned surface vehicles increase the standoff, reach, and distributed lethality of the manned platforms they support.

As the unmanned option of choice, the USV, or multiple USV operating together, gain vital and necessary intelligence information without putting a Sailor or Marine in harm's way.

The importance of using unmanned systems in the ISR and IPB roles was emphasized by the deputy assistant secretary of the Navy for research, development, test and evaluation, Mr. William Bray, in an interview with U.S. Naval Institute News where he said: "Responding to a threat today means using unmanned systems to collect data and then delivering that information to surface ships, submarines, and aircraft. The challenge is delivering this data quickly and in formats allowing for quick action."[25]

While the Navy is committed to buying large numbers of unmanned maritime vehicles, it has yet to come up with a convincing concept of operations for how they will be used during conflict against a determined adversary. The U.S. Congress has indicated increasing skepticism that the billions of dollars the Navy intends to invest in these platforms should continue, absent a clear understanding of their intended use. Indeed, a mid-2020 article in a defense publication reported this Congressional concern this way:

"The Navy has yet to produce a concept of operations or even a coherent public strategy to back up the investments they want to make. Further, Congress is wary of appropriating money for platforms that rely on technologies that haven't been fully developed yet."[26]

The inability of the Navy to develop a convincing CONOPS for the use of unmanned maritime systems may simply stem from a lack of imagination. As the Navy looks to allay Congressional concerns and accelerate the fielding of unmanned maritime systems, the emphasis should be on no longer thinking of each unmanned maritime system as a "one-of," but rather, to package these together as in multiple-sized and function vehicles designed for specific missions.

The emphasis must remain on USV ship design that is focused on modularity to accommodate sensors, weapons and payloads for specific missions, where the platform remains constant and the modularity within the platform allows for the "modular shift" to support multiple missions.

Shaping, and executing a CONOPS for the use of unmanned maritime systems is crucial to be able to introduce these new capabilities into the fleet in a way which reinforces fleet wide warfighting innovations in the high-end fight without degrading the fleets capabilities to do so.

[1] Max Boot, ***War Made New: Technology, Warfare, and the Course of History 1500 to Today*** (New York: Gotham Books, 2006), pp. 318-351. See also, Bruce Berkowitz, ***The New Face of War: How War Will Be Fought in the 21st Century*** (New York: The Free Press, 2003).

[2] Bruce Berkowitz, ***The New Face of War: How War Will Be Fought in the 21st Century*** (New York, The Free Press, 2003), pp. 2-3. Berkowitz does not restrict his examples to just one conflict, noting further; "The same thing happened when the United States fought Yugoslavia in 1999 and the Taliban regime in Afghanistan in 2001. Each time experts feared the worst; each time U.S. forces won a lopsided victory."

[3] ***Quadrennial Defense Review*** (Washington, D.C.: Department of Defense, 2014).

[4] Jason Sherman, "DoD's New Unmanned Systems Roadmap Charts Course for AI, Weaponization," ***Inside the Navy***, September 3, 2018.

[5] Department of Defense, ***Joint Operational Access Concept***, (Washington, D.C.: Department of Defense, January 2012).

[6] ***Joint Concept for Access and Maneuver in the Global Commons*** (Washington, D.C.: Department of Defense, 2017), accessed via a January 27, 2017 Joint Forces Quarterly article: https://ndupress.ndu.edu/Media/News/Article/1038867/joint-concept-for-access-and-maneuver-in-the-global-commons-a-new-joint-operati/.

[7] ***The Future Navy*** (Washington, D.C.: Department of the Navy, May 2017) accessed at: http://www.navy.mil/navydata/people/cno/Richardson/Resource/TheFutureNavy.pdf

[8] See, for example, "Document, Summary of the Navy's New Force Structure Assessment," ***USNI News***, December 16, 2016 (updated April 6, 2017) accessed at: https://news.usni.org/2016/12/16/document-summary-navys-new-force-structure-assessment, for an executive summary of this document.

[9] ***FRAGO 01/2019: A Design for Maintaining Maritime Superiority***.

[10] ***Advantage at Sea: Prevailing with All-Domain Naval Power*** (Washington, D.C.: Department of the Navy, December 2020) accessed via ***USNI News***, December 17, 2020, at: https://news.usni.org/tag/advantage-at-sea-prevailing-with-integrated-all-domain-naval-power.

[11] Megan Eckstein, "Navy Pursuing 'Surface Development Squadron,' to Experiment with Zumwalt DDGs, Unmanned Ships," ***USNI News***, January 28, 2019.

[12] Kris Osborn, "Navy to Test 'Ghost Fleet' Attack Drone Boats in War Scenarios, ***Defense Maven***, January 22, 2019.

[13] See, for example, Ronald O'Rourke, ***Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress*** – CRS Report 45757 (Washington, D.C.: Congressional Research Service, October 7, 2020). While the primary focus of the report is on larger unmanned surface vehicles, it provides a comprehensive overview of the Navy's plans for large, as well as medium sized craft. For a brief summary of an earlier report, see Report to Congress on Navy Large Unmanned Surface and Undersea Vehicles, ***USNI News***, June 11, 2019, accessed at: https://news.usni.org/2019/06/11/report-to-congress-on-navy-large-unmanned-surface-and-undersea-vehicles?utm_source=USNI+News&utm_campaign=24af1c52bf-USNI_NEWS_DAILY&utm_medium=email&utm_term=0_0dd4a1450b-24af1c52bf-230420609&mc_cid=24af1c52bf&mc_eid=157ead4942.

[14] David Larter, "U.S. Navy Looks to Ease Into Using Unmanned Robot Ships With a Manned Crew," ***Defense News***, January 29, 2019. ADD

[15] Eckstein, "Navy Betting Big on Unmanned Warships Defining Future of the Fleet."

[16] Megan Eckstein, "Navy Planning Aggressive Unmanned Ship Prototyping, Acquisition Effort," ***USNI News***, May 15, 2019. Accessed at: https://news.usni.org/2019/05/15/navy-planning-aggressive-unmanned-ship-prototyping-acquisition-effort. For additional reporting on the U.S. Navy's plans to integrate unmanned surface vehicles into the Fleet, see, also, David Larter, "With Billions Planned in Funding, the US Navy Charts

Its Unmanned Future," ***Defense News***, May 6, 2019. Accessed at: https://www.defensenews.com/digital-show-dailies/navy-league/2019/05/06/with-billions-planned-in-funding-the-us-navy-charts-its-unmanned-future/.

[17] Megan Eckstein, "Navy Betting Big on Unmanned Warships Defining Future of the Fleet," ***USNI News***, April 8, 2019. Accessed at: https://news.usni.org/2019/04/08/navy-betting-big-on-unmanned-warships-defining-future-of-the-fleet.

[18] ***Naval Research and Development: A Framework for Accelerating to the Navy and Marine Corps After Next***.

[19] ***Naval Research Enterprise Addendum to the Naval Research and Development Framework***.

[20] ***Navy Program Guide***, accessed at: http://www.navy.mil/strategic/npg17.pdf, and ***Marine Corps Concepts and Programs*** accessed at: https://www.candp.marines.mil/.

[21] Jon Harper, "Navy Officials Speed Up Acquisition of Unmanned Maritime Systems," ***National Defense Magazine*** Online, January 11, 2018, accessed at: http://www.nationaldefensemagazine.org/articles/2018/1/11/navy-officials-under-pressure-to-speed-up-acquisition-of-unmanned-maritime-systems. See also Richard Burgess, "Navy Acquisition Chief: 'Reliably Deliver Capable Capacity,'" ***SEAPOWER Magazine Online***, January 11, 2018, accessed at: http://seapowermagazine.org/stories/20180111-geurts.html. ADD

[22] Ronald O'Rourke, ***Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress*** – CRS Report 45757.

[23] Remarks at the 2019 Navy League of the United States SeaAirSpace Symposium, National Harbor, Maryland, May 6-8, 2019.

[24] The Navy has begun testing the connectivity between unmanned systems in all three domains: air, surface and subsurface. See, for example, Vladimir Djapic et al, "Heterogeneous Autonomous Mobile Maritime Expeditionary Robots and Maritime Information Dominance," ***Naval Engineers' Journal***, December 2014.

[25] Ben Werner, "Sea Combat in High-End Environments Necessitates Open Architecture Technologies," ***USNI News***, October 19, 2017, accessed at: https://news.usni.org/2017/10/19/open-architecture-systems-design-is-key-to-navy-evolution?utm_source=USNI+News&utm_campaign=b535e84233-USNI_NEWS_DAILY&utm_medium=email&utm_term=0_0dd4a1450b-b535e84233-230420609&mc_cid=b535e84233&mc_eid=157ead4942.

[26] David Larter, "The Pentagon Wants To Forge Ahead With Robot Warships, But Congress Wants To Slow The Train," ***Defense News***, June 19, 2020.

Manned-Unmanned Collaboration: The Case of the U.S. Navy

February 8, 2021

By Robbin Laird

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With the shift from land wars to conflicts in contested air and sea spaces, new concepts of operations and systems are developing. The terms anti-access and area denial have been coined to describe how certain competitors (notably Russia and China), are shaping their capabilities in an attempt to ensure combat dominance in times of direct conflict, but also to underwrite other forms of combat operations, such as "gray zone" operations or hybrid-war concepts of operations.

The core military challenge for liberal democracies is to operate decisively in a contested combat environment to protect their interests – and not allow the 21st century authoritarian powers to rewrite the rules of the game.

As Admiral Gilday, the Chief of Naval Operations, recently put it in testimony before the U.S. Senate: "Despite benefiting from decades of peace and stability, China and Russia are now using all elements of their national power to undermine the international order at sea. Both attempt to unfairly control access to rich sea-based resources outside their home waters. Both intimidate their neighbors and enforce unlawful claims with the threat of force. Both have constructed sophisticated networks of sensors and long-range missiles to hold important waterways at risk. And China, in particular, is building a Navy to rival our own."

A number of new platforms and capabilities have already been introduced by the United States and core allies and partners to reshape approaches and training for new concepts of operations to deal with the new challenges. New maritime patrol capabilities, surface and sub-surface platforms, missile defense and strike missile systems, and new combat aircraft are all coming into the forces. Along with those new capabilities, new multi-domain training approaches are being introduced as well.

But figuring out the best ways to leverage remotes in combat operations is clearly a work in progress, and lessons learned with initially deployed systems will provide a path to shaping a way ahead. The challenge is not just to build and use remotes, but how to communicate and use the data they gather for proper combat effect. Indeed, one way to look at the impact of remotes is upon the challenges they pose to the networks through which such systems would be managed.

In this article, I will draw upon two different systems that highlight both the potential and the challenges for shaping a way ahead for manned-unmanned teaming or collaboration. The first is with regard to Triton and the second is related to counter-mine operations at sea.

The Case of the Triton

There is an expectation that unmanned or remote systems are part of how the U.S. and the allies will shape effective forces going forward. At the heart of that effort will be an expanded leveraging of these systems, and shaping ways for manned and unmanned systems to collaborate.

A key area in which the U.S. Navy is already doing this, is anti-submarine and anti-surface warfare. Here, the key element has been the introduction of the Triton unmanned system working with the manned, fixed-wing P-8 maritime patrol aircraft (MPA) and the Romeo helicopter.

This year, I have visited Norfolk, Jacksonville, Florida, San Diego, and Fallon Naval Air Station, the home of the Naval Aviation Warfighting Center or NAWDC. During those visits I had significant opportunities to talk with senior Naval officers, operators of both P-8s and Tritons, as well as the other key assets in maritime warfare that are most central to shaping a way ahead with the ISR/C2 enabled air combat force. This effort included visiting the USS Gerard R. Ford in October and November 2020, where the new carrier will be incorporating data from the maritime patrol community, including Triton, to shape its way ahead in conducting 21st century ISR-enabled combat.

The U.S. Navy's approach to working maritime patrol functions relies on the new manned aircraft, the P-8 MPA; the Romeo variant of the Sea Hawk helicopter; and the unmanned Triton. With these three systems, the

Navy is working through how to handle the data necessary to make timely decisions to execute the anti-submarine and anti-surface warfare missions.

Earlier this year, Captain Matthew Pottenburgh, the Commodore in charge of Patrol and Reconnaissance Wing Eleven, highlighted during an interview with me in Jacksonville how these manned assets are working with the Triton.

The USAF remote piloted operating community is isolated from the manned pilots, whereas the P-8 and Triton operational community is unique in the U.S. military in that personnel rotate between the two platforms. This has led to the formation of a new generation of operators who cross-train for both manned and unmanned IRS platforms.

What is being shaped are coordinated operations between the two, where the Triton can sweep the field of operations to identify targets and allow the P-8s to focus directly on those targets – where they need to go, and what they need to do.

While the P-8 can operate with autonomy and networkability, the Triton is a network-generating, network-enabling asset. The vast amounts of data provided by Triton is requiring the Navy and the joint force to rework how to handle data flows from the unmanned asset to gain combat advantages. Put another way, traditional methods of handling data are not adequate to properly manage such massive amounts of information). In fact, learning how to manage data from Triton has been a key driver for change in how to redesign the ISR to C2 empowerment systems, which the U.S. Navy seeks to execute distributed maritime operations.

The unmanned asset operates differently from the P-8 or the Romeo in a way that is also leading to adjustments. For instance, both the P-8 and Romeo sortie into an operational area, operate for a period of time and land (either on land in the case of the P-8 or on a ship in the case of the Romeo helicopter). The concept of operations for the Triton, however, is very different. Triton provides the U.S. Navy with a whole new level of situational awareness that the Navy would attain no other way. With 24/7 coverage of the area, and in continuous orbit at 3000km, the Triton can provide domain awareness knowledge crucial to informing the threat and opportunity calculus for the area of operations.

The Triton/P-8 dyad then, poses a significant challenge to reworking the C2/ISR enabled force. Without enhancing the data management network side of the challenge, the ability to leverage the data generated by Triton will not be maximized.

The data backbone for Triton is not yet completely there. But by deploying Triton, the Navy and the Air Force are moving forward with new ways for data management and to flow ISR more effectively into decision making systems. But again, this is being driven by operational experience of the Triton and other new air systems, and adaptation is based on real world experience, not an abstract science project.

There is clearly a cultural learning process as well. The MPA community has operated throughout its history based on a concept of operations driven by air platform sortie operations. The Triton is based on a multi-aircraft orbit concept of operations which yields a very different data stream than one gets from an air sortied aircraft – somewhere between what space systems deliver and what the sortied air collection platforms can deliver.

And given that the Triton is engaged in tasking, collecting, processing, exploitation and dissemination of information in real time, learning how to do this for the fleet is a crucial challenge facing the future of a kill web enabled force.

As Triton gains multi-INT or multi-intelligence capabilities, it will become a more effective platform to contribute to the collaborative effort where multiple sensors can be cross-referenced to provide greater fidelity on targeting, and notably when it comes to smaller vessels of interest as well.

What the Triton experience has demonstrated, without a doubt, are the challenges that unmanned or remote systems pose to the C2 and ISR networks. By navigating effective ways ahead with regard to network and C2 innovations, the role of remotes will be reduced and their contributions more limited than might otherwise be the case.

Again, the Chief of Naval Operations has highlighted how to look at the challenge. Referring to maritime remotes, he had this to say: "Those vessels are useless unless we can command and control them with a very high degree of precision and reliability. And so that's where we start talking about the Navy's Project Overmatch, that falls underneath, or nests underneath JADC-2. And so there are four big pieces to that. It's the networks. It's the infrastructure. It's the data standards.

"And then finally, it's the capabilities, whether they're battle management aids or whether they're artificial intelligence and machine learning capabilities that we apply to that data that allow us to decide and act faster than the bad guy, and then deliver ordnance faster out of these unmanned platforms."

An Approach to Counter-Mine Warfare

An alternative approach to leveraging maritime remotes is to work with them within the realm of the operational space of a ship, and then to deliver information from the ship to the relevant members of the operational fleet.

During a visit to San Diego earlier this year, I had a chance to look at a demonstration of how this might work with a new counter-mine system featured at Trident Warrior 2020 which was held in San Diego from 13-16 July 2020. There is a compelling need creatively to apply new, innovative technologies to address the operational and tactical challenges posed by mines, as well as the need to expand the use of unmanned systems to tackle Mine Countermeasure Mission (MCM) challenges.

Meeting this demand with COTS hardware and software – and not wagering on emerging technologies that will take years to develop, mature and field—should be a priority for Navy and Marine Corps planners. Rear Admiral Casey Moton, Program Executive Officer, Unmanned and Small Combatants (PEO USC), has stated that one of the functions of his office is to ensure that unmanned systems the Navy seeks to buy have the right level of technical maturity, especially in the most basic hull, mechanical and electrical (HME) attributes.

This strongly suggests that the Navy would be well-served to move forward by focusing on COTS technologies that have been wrung out in Navy and Marine Corps exercises, experiments and demonstrations. This will ensure that these systems have the requisite HME attributes and maturity to succeed.

What I saw in San Diego were all the component parts of what several industry representatives, led by Teledyne Brown Engineering Inc, brought together to demonstrate an autonomous MCM solution that takes the Sailor out of the minefield. It is important to emphasize that every component part of this solution has been in the water and tested in the operational environment.

I witnessed what each individual component could do, and received a briefing on how Teledyne Brown has an integrated solution—dubbed "Clear-Sea" – to pull all these components together and achieve a single-sortie detect-to-engage MCM capability. The "mother ship" for all the components of this Clear-Sea MCM capability demonstrated in San Diego was the T38E (38-foot extended) MANTAS high-speed catamaran.

Earlier versions of the MANTAS have been proven in numerous Navy and Marine Corps exercises, experiments and demonstrations.

I rode on the MANTAS and noted how the catamaran hull allows the boat to slice through choppy waters and provide a smooth ride that mono-hulls cannot. I also noted how the size of the vessel can easily accommodate the mine-hunting and mine neutralizing systems that complete the system.

The planned production T38 is similar in size to an eleven-meter RHIB carried by many U.S. Navy ships and thus can be easily integrated aboard most U.S. Navy warships. In comparison to an eleven-meter RHIB, the T38 is two feet longer, five inches wider, drafts 17 inches shallower at max displacement, and includes a cross-section height over eight feet lower, making it extraordinarily hard to detect. The T38 can operate in up to sea state five, has a cruise speed equal to, and a maximum speed twice that of an eleven-meter RHIB.

The first component that I saw – and that will be carried by the T38 – is the ThayerMahan Sea Scout subsea imaging system. The Sea Scout is specifically designed for missions such as mine hunting. The Sea Scout system is founded on the in-production COTS system Kraken Robotics Katfish-180 tow-body mounted Synthetic Aperture Sonar. The system is designed to search for mine-like objects (MLOs), and is integrated by ThayerMahan's remote operations and communications system.

I learned that this system can survey up to three and a half kilometers per hour at a resolution sufficient for MLO classification, and is programmable for bottom following, terrain referencing, obstacle avoidance, and "flies" at a pre-programmed depth. Automatic Target Recognition identifies likely MLO anomalies, which are then presented in near-real-time to the man–in-the-loop for verification as an MLO. Verified MLOs are added as a waypoint for validation, while invalid MLOs are discarded or passed to the navigation database as a hazard to navigation. Verified MLOs are continuously updated to a recommended route for the Mine Neutralization System (MNS) Remotely Operated Vehicle (ROV).

The next component I saw was the Idrobotica Pluto Plus MNS ROV which executes the "dull, dirty and dangerous" work previously conducted by classes of U.S. Navy ships by providing real-time HD video validation of mine-like objects. It too will be carried by the T38. I was briefed on how this MNS ROV autonomously executes the MLO route for final classification and man-on-the-loop validation of each MLO while the T38 shadows and supports it as an over-the-horizon communications link and countermine charge supply link. Once the operator identifies a validated MLO as a likely mine that must be destroyed, an explosive charge is placed on the mine.

The MNS ROV then clears the area. The classification, validation and engagement processes are then repeated until the field is cleared. The countermine charge detonation sequencing may be altered to detonate in any order and at any time desired. I was able to see what these sensors found during their several-week operation from the Idrobotica Pilota Watch-Stander Station.

I was struck by the fact that this watch station is manned by a single individual.

This system and its software architecture accommodate integration of variable depth sonar or hull mounted sonar, AUV and ROV functions, auto-pilot control and propelled variable depth sonar. I noted that the fidelity of the images displayed on this watch station left little doubt as to the identity of what was observed.

While each component in this system was impressive in its own right, that is not enough – not by a long shot. These individual components must be fully integrated in order to deliver the subsystems as a cohesive turn-key unmanned MCM solution that is easy to operate and easy to maintain. Teledyne Brown Engineering has a deliberate plan to do just this and is prepared to demonstrate incrementally more integrated versions of what I observed in San Diego.

Importantly, from my point of view, among all the MCM solutions I have examined in my years following (and writing about) this mission area, this one stands out as a very capable single-sortie detect-to-engage MCM capability solution.

With regard to manned-unmanned collaboration, this kind of solution allows for the data that is collected onboard the vessel, gets interpreted for the anomalies back to the professionals onboard the fleet. This means that one does not need a wide area network to deliver the desired mission effect, but one tied back to the operating ship, which can then use a variety of communication tools to provide data with regard to the mine threat and the results from the counter-mine operations.

In other words, Triton highlights the broader opportunities which remotes can deliver to the wide area network; and counter-mine case highlights how networks can be focused on a core mission without the need to rely on a broader network. Progress on both sides will be key to sorting through the opportunities which unmanned or remote systems can provide the operating forces.

Shaping a Maritime Kill Web Transition: The Case of the MQ-25

June 11, 2020

By Robbin Laird

In my recent interviews with the senior officers working at the Naval Aviation Warfighting Development Center or NAWDC, it is clear that there is a major shift in training for and shaping the way ahead for the air-maritime force. We have visited NAWDC twice before doing these interviews and the shift over the past few years is dramatic.

The shift has been from traditional CSG training to what I have coined the rise of the integratable air wing. In my discussion with the Navy Air Boss, Vice Admiral Miller, we discussed the shift. What is underway is a shift from integrating the air wing around relatively modest and sequential modernization efforts for the core platforms to a robust transformation process in which new assets enter the force and create a swirl of transformation opportunities, challenges, and pressures.

How might we take this new asset and expand the reach and effectiveness of the carrier strike group?

How might it empower maritime, air, and ground forces as we shape a more effective (i.e. a more integratable) force?

One of the examples which we discussed was the coming of the MQ-25 or the Stingray.

“Vice Admiral Miller provided several other examples of how this shift affects the thinking about new platforms coming onboard the carrier deck. One such example is the new unmanned tanker, the MQ-25.

“The introduction of this new air asset will have an immediate effect in freeing up 4th gen fighters, currently being used for tanking, to return to their strike role. Even more importantly from a transformation perspective, the MQ-25 will have operational effects as a platform which will extend the reach and range of the CVW.

“But MQ-25 will be a stakeholder in the evolving C2/ISR capabilities empowering the entire combat force, part of what, in my view, is really 6th generation capabilities, namely enhancing the power to distribute and integrate a force as well as to operate more effectively at the tactical edge.
“The MQ-25 will entail changes to the legacy air fleet, changes in the con-ops of the entire CVW, and trigger further changes with regard to how the C2/ISR dynamic shapes the evolution of the CVW and the joint force. The systems to be put onto the MQ-25 will be driven by overall changes in the C2/ISR force. These changes

are driving significant improvements in size, capability, and integration, so much so that it is the nascent 6th gen.

"This means that the USN can buy into "6th gen" by making sure that the MQ-25 can leverage the sensor fusion and CNI systems on the F-35 operating as an integrated force with significant outreach."
I have had a chance to continue this discussion about the coming of the Stingray with officers at NAWDC.

And this impact can be seen in no less than three warfighting programs at NAWDC.

The first is the school where Stingray "will report" when it becomes operational,

"The cluster of innovation with the coming of the MQ-25A is being led by the transition from the legacy Hawkeye to the Aerial Refueling modified E-2D (AR) Advanced Hawkeye, which provides a game changing capability to a carrier air wing through advanced sensors & C2 networking capabilities, persistent presence, and greater operational reach.

"That point was driven home to me in a discussion with CDR Christopher "Mullet" Hulitt, head of "CAEWWS," the Navy's airborne command & control weapons school located at Naval Aviation Warfighting Development Center (NAWDC) at Naval Air Station Fallon.

"As the cluster evolves, the notion of a platform-centric functional delivery of airborne early warning and battle management shifts to a wider notion of providing support to the distributed integrated combat force which flew off of the carrier and adjacent capabilities working with the air maritime deployed kill web."

The second is the impact of MQ-25 on other assets being used in the SA and strike efforts generated from the sea base.

Recently, I had the chance to talk with CDR Jeremy "Shed" Clark, Senior Leader at the Naval Rotary Wing Weapons School (SEAWOLF) at NAWDC. The Seawolf School focuses on Romeo, Sierra, and Fire Scout training, with Romeo being the sensor rich ASW/SUW/EW and related tasked focus helo onboard the Navy's large deck carriers.

And why would one mention the Stingray in relationship to the Rotary Wing Weapons School?

"We discussed the coming of the MQ-25. The Romeo community is already looking at how having sensors onboard the MQ-25 can expand the reach and range of what the Romeo's onboard sensors can accomplish for the maritime distributed force.

"It is also the case that as sensor demands currently made on the Romeo can be shifted elsewhere.

"The Romeo can refocus its task priorities and enhance its contributions to broader mission sets such as ASW and to focus on contributing capabilities that other platforms within the strike group are not prioritized to perform."

The third is the MISR school, or the Maritime ISR school.
Here NAWDC is training officers to provide for ISR knowledge guidance to the fleet and within fleet commands. They are not platform specific, so whatever contribution MQ-25 will make will flow into the MISR knowledge zone for management.

And it is not just about NAWDC but the joint force as well.

One example is a recent discussion I had with officers at USMC Aviation headquarters.

Here we focused on new ways to work the amphibious task force for sea control and sea denial and changes to the Viper attack helicopter which could allow it to work differently with Seahawk.

And because Seahawk was going to operate differently because of the coming of the MQ-25 this could flow down into new capabilities for the L-class ships configured as an amphibious task force.
To be blunt, if you had a traditional kill chain approach you would not be looking for these kinds of cross cutting synergies.

But not only are they there, but a new approach to working with industry, and leveraging software upgradeable platforms can accelerate the crafting, enhancing and extension of kill web capabilities.
Recently, I had a chance to talk with a senior Boeing executive involved with the Stingray program. We had met earlier, when the Second Line of Defense team visited the Boeing plant in Philadelphia to talk about Osprey and learn from the Boeing team how they approached design and manufacturing issues involved with the program.

Since that time Kristin Robertson has become vice president and general manager of Autonomous Systems within Boeing Defense, Space and Security, where her division focuses on autonomous technologies, intelligence capabilities and networking solutions from sebed to space.
From my point of view, the key point is how Boeing is working with the US Navy in a new way to deliver a kill web product.

Clearly, MQ-25 falls into that transformation space.

The MQ-25 is one of three US Navy rapid acquisition programs, and it is clear that the core function of the MQ-25 is to do fleet tanking and that is the core mission priority.

But as highlighted earlier, being able to do that means as well as that the question is how to leverage the operational envelope of the MQ-25 to add other module capabilities, notably, in the C2/ISR world.

According to Robertson, the US Navy has been clearly focused on building the MQ-25 baseline in such a way that ability to grow capabilities is inherent in that baseline.

“We know we have to be a tanker first and we’re on track.

“The program has been very successful with the development program on track, on schedule.
“We have built significant margin into the baseline.”

And unlike Triton, the MQ-25 flies at altitudes where it has to be able to work with commercial and other piloted aircraft in the airspace as well.

This means that the aircraft clearly needs to have significant maturity to operate in a more congested airspace compared to Triton which is almost a LEO.

What this highlights is the importance of what new platforms can do.

Even though discussions of C2/ISR often focus on platform agnostic discussions, in fact, getting new platforms right to provide for a wider array of C2/ISR capabilities is crucial.

The MQ-25 is a case in point where the engine, the materials technologies, the navigability, the ability to work with various elements of autonomous systems whether in remotely piloted aircraft or manned aircraft, all are required to conduct the core mission and contribute seamlessly to C2/ISR and strike enablement missions.

The design of the system is built around an open architecture which allows for very flexible upgradeability over time.

And part of this approach to upgradeability is clearly to be able to add third-part applications when the US Navy deems a particular app as crucial to their mission sets.

A significant change which I have observed at NAWDC, Nellis or MAWTS-1 is that the military teams are a key part of shaping the development process.

This has been largely neglected in analysis of innovation being affected by today's Navy and Marine Corps but is clearly on the way.

The MQ-25 program has picked up this important dynamic of change within which the Boeing and Navy development teams are tapping into operator judgements about shaping a way ahead for the platform as well.

Robertson underscored: "The whole idea with rapid acquisition programs is the need to build in early learning and then roll what is learned into the next phase of program development.

"The Navy is working to shape new ways to validate and verify program results differently to get the kind of innovation they want and to do so more rapidly as well.

"They are taking calculated and deliberate approaches to shape a way ahead."

Recently, I spoke with Rear Admiral Rich Brophy, Commander NAWDC, and he underscored that "the Navy was building some solid footholds on quickly shaping the maritime kill web force from innovation, to integration, to training."

And he sees this as crucial for the way ahead for the Navy, the joint and the coalition force.

Clearly, the MQ-25 program is one such foothold on the path forward.

Unmanned Systems Take the Sailor Out of the Minefield

By George Galorisi

February 20, 2020

During the past several months, NATO has been flexing its mine-countermeasures and engaging commercial companies to deal with mines and other unexploded ordnance, much of it dating back to World War II. Indeed, as part of this process, NATO has constituted its 1st Standing Anti-Mine Squad and the Baltic Minesweeper Squadron (BALTRON).

As previously reported in ***Second Line of Defense,*** in November 2019, NATO MCM ships cleared more than fifty mines from the Baltic Sea.

More recently, the Estonian maritime security company, ESC Global Security, won a Polish tender worth four million euros for clearance of approximately the sea bottom of old mines on the route between several ports.

Few would disagree with the statement that mines represent one of the most vexing military challenges, and the fact that NATO nations are keen to clear mines that have been on the sea floor for over seven decades is telling regarding just how challenging the MCM mission remains to this day. Sea mines are perhaps the most lethal form of these weapons, as they are hard to find, difficult to neutralize, and can present a deadly hazard to any vessel—even those ships specifically designed to hunt them. These "weapons that wait" provide almost any adversary with an effective means to thwart even a major naval power.

The threat of mines can stop any naval operation dead in its tracks. The use of sea mines adjacent to maritime choke points presents a threat that is at once ubiquitous and deadly. Further afield, sea mines have broader repercussions for global maritime trade routes as well. Sadly, western nations have given insufficient attention to dealing with the threat sea mines pose to naval and merchant activities worldwide.

This mission is of vital importance to the United States as well as to many other nations. As reported in USNI News: "The Navy's mine warfare community is putting together a comprehensive plan to lay out the investments required for a successful transition from legacy mine countermeasures systems to more advanced capabilities."

The same article pointed out the urgency of the situation:

"The early-1980s Avenger-class MCM ships and the mid-1980s MH-53E Sea Dragon helicopters will be on their way out next decade, and a mix-and-match system of sensors, offboard vehicles and platforms will take over the mission. Though Navy leaders knew the transition was coming – and though it's been pushed back due to delays in developing capabilities within the Littoral Combat Ship (LCS) program – decisions related to retiring the legacy systems have now come into the near-term planning window for the service, requiring a coordinated path forward on the transition."

"While the United States and many of its NATO and other allies are laying up and "sun-setting" their mine-countermeasures (MCM) capabilities, peer competitors are enhancing their MCM inventory. In late 2019, Russia christened a new Alexander-Obukhov-class minesweeper, adding to their already substantial fleet of Aleksandrit-class and Natya-class minesweepers. China added new Wozang-class mine-countermeasures vessels in 2016 (Rongcheng and Donggang types) and in 2017 (Rudong type).

The Ongoing Challenge to Instantiate Effective Mine Countermeasures

Today, especially given the tensions between the United States and Iran, U.S. and allied military professionals are evaluating the ways that Iran could threaten the west. Many think that the most serious threat is that Iran could mine the Strait of Hormuz. The mines themselves would not only take an extended period to clear, but the minesweepers could only do their work once the Iranian navy was sunk and its anti-ship missile sites destroyed.

Beyond the Iranian threat, the challenge posed by potential adversary mining capabilities is real and growing. The number of countries with mines, mining assets, mine manufacturing capabilities, and the intention to export mines has grown dramatically over the past several decades. More than fifty countries possess mines and mining capability. In addition, the types, sophistication, and lethality of the mines available on the world market are increasing.

This threat is not lost on Navy and Marine Corps leadership. During the November 2019 NDIA Expeditionary Warfare Conference, Vice Admiral John Miller, former commander of Naval Forces Central Command, noted that developing MCM capability is critical as the Navy faces increased mining threats from adversaries worldwide. During this event, Major General David Coffman, Commanding General of the 1st Marine Expeditionary Brigade noted, "The threat of mines is growing globally. It is an asymmetric advantage that our enemy is trying to leverage and directly affects our maneuverability and our assets."

It falls on the U.S. Navy to provide the MCM capability to enable the Joint Force to operate forward in support of United States' interests, as well as those of our allies and friends. Indeed, the U.S. Navy's strategic document A Design for Maintaining Maritime Superiority 2.0 (Design 2.0) articulates the profoundly challenging strategic environment where peer competitors such as China and Russia and lesser, but more unstable, powers such as North Korea and Iran, have large inventories of naval mines. Design 2.0 notes that, "It has been decades since we last competed for sea control, sea lines of communication and access to world markets." The threat of naval mines is one of the key challenges that drives our emerging need to once again compete for freedom of movement on the world's oceans, as well as in the littorals.

Mine Countermeasures (MCM) is one of the most difficult and time-consuming missions for navies to successfully execute. The U.S. Navy's MCM capabilities are little-changed today, even after decades of "aspirational" intentions to enhance the Navy's MCM posture. While the U.S. Navy has made some important strides, such as the MCM package aboard the Littoral Combat Ship (LCS), the significance of the MCM mission provides both the impetus and opportunity to do much more. And the time to do so is now.

The platforms that embody the U.S. Navy's primary MCM capability—the MH-53E AMCM aircraft and the Avenger-class minesweeper – are scheduled to sunset by 2025. As Captain Chris Merwin of the Naval Surface and Mine Warfighting Development Center (SMWDC) pointed out at a military-industry event in October 2019, the Navy's follow-on MCM capability, embodied the MCM package aboard the Littoral Combat Ship (LCS), is not coming on line as rapidly as anticipated, and initial operating capability is not scheduled until 2023 – a date Captain Merwin described as "optimistic."

This is not a new issue for the U.S. Navy, but one it has struggled with for decades. While there are many reasons why the U.S. Navy has not yet developed a more effective MCM capability, most would put technology at the top of the list. The mission is complex and all of today's technological solutions still put the Sailor in or near the minefield. New technologies are urgently needed.

Unmanned Maritime Vehicle Technologies Are Evolving Rapidly

Today, one of the most rapidly growing areas of innovative technology adoption by military forces worldwide involves unmanned systems. In the past several decades, the expanding use of military unmanned systems (UxS) is already creating strategic, operational, and tactical possibilities that did not exist a decade ago.

While unmanned systems show great promise, most military professionals are keenly aware of the importance of not embracing every tool a technologist thinks might be of value to those in the fight. Employing unmanned systems in an ongoing series of exercises, experiments and demonstrations is a proven way of separating promising, but immature, technologies from those that will actually wind up in the hands of a warfighter as a proven capability.

Given today's compelling mine threat, as well as the age of current MCM force, to say nothing of the rapidity with which current MCM systems are sun-setting, it may be time for naval professionals to shift to a new technology paradigm and focus on technologies—often commercial-off-the-shelf (COTS) technologies—will likely deliver an MCM capability faster than traditional acquisition processes.

For all navies, there is only one way to completely, "Take the sailor out of the minefield," and that is to leverage unmanned technologies to hunt and destroy mines from a distance. The severe damage done to U.S. Navy ships, USS Samuel B. Roberts, USS Tripoli and USS Princeton by simple sea mines is something that can be avoided in the future. In the past, unmanned vehicle technologies were not mature enough to be considered to take on the complex mine-hunting and mine-clearing task. They are today.

Other navies can capitalize on the work that the U.S. Navy has already conducted as it has explored ways to use emergent COTS unmanned technologies for the MCM mission. Given the severity of the mine threat, all navies would be well-served to leverage and build upon mature technologies that have been examined by commercial and other government agencies in the United States, and tested extensively in exercises, experiments, and demonstrations to field a near-term MCM capability.

Leveraging U.S. Navy and Marine Corps Experience

Earlier in this article I quoted both a U.S. Navy admiral and a U.S. Marine Corps general, both of who spoke of the severity of the mine threat as well as the challenges of fielding an effective and affordable MCM capability. This was not a set of random quotes, but rather an indication that the Navy and Marine Corps are united in their mutual efforts to deal with the worldwide mine threat to naval expeditionary forces.

The reason for this unity of effort is clear: Navy-Marine Corps expeditionary strike groups operate in the littorals close to shore, often on a coastline that the adversary defends with mines. That is one of the reasons why, over the past several years, in a series of U.S. Navy and Marine Corps events as diverse as the Ship-to-Shore Maneuver Exploration and Experimentation and Advanced Naval Technology Exercise (S2ME2 ANTX), the Battlespace Preparation in a Contested Environment, the Surface Warfare Distributed Lethality in the Littoral demonstration, Dawn Blitz, Steel Knight, the Bold Alligator exercise series, and Valiant Shield, operators have field-tested wide range of emerging technologies, many of them adaptable to the MCM mission.

One of the technologies that performed well in these events was the MANTAS unmanned surface vehicle (USV). Over the course of the events described above, the MANTAS was scaled-up from a six-foot, to eight-foot, to twelve-foot version. During Exercise Valiant Shield, MANTAS was tasked with re-supply mission, carrying cargo to the troops ashore. As a result of that mission success, U.S. Navy and Marine Corps officials have asked MANTAS' manufacturer, MARTAC Inc., to scale-up the MANTAS further and design a thirty-eight-foot version.

It is this USV—one that approximates the size of an eleven-meter RHIB used by many navies—that can be combined with surface and subsurface mine-hunting and neutralizing equipment to provide an over-the-horizon "single sortie detect-to-engage" MCM capability that takes the sailor out of the minefield and provides a potential solution for this challenging mission. While there are any number of USVs and UUVs that the U.S. Navy is testing, leveraging one that has been thoroughly wrung out for hundreds of hours during years of Navy exercises, experiments, and demonstrations provides the most important building block for a comprehensive MCM capability….

The Next Revolution in Military Affairs?

May 31, 2021

By Robbin Laird

Recently, USNI press has published a book edited by Sam J. Tangredi and George Galdorisi entitled *AI at War: How Big Data, Artifical Intellignece and Machine Learning are Changing Naval Warfare.*

The book provides a useful overview to various perspectives on how AI and autonomous systems might shape the way ahead with regard to the evolution of warfare.

In effect, the art of warfare is changing under the impact of several forces for change, not simply how data is managed or how machines might operate as force extenders for manned platforms.

In reality, the book really focuses on command and control, and many of the chapters focus on that subject.

The shift from the land wars back to peer competitor warfare is built around the return of mission command and C2 as the heart of shaping the way ahead for distributed forces.

The standup of Second Fleet in Norfolk and the associated commands under VADM Lewis's leadership are being crafted into a warfighting force around mission command and distributed C2 and reworking task force concepts.

Autonomous systems and better information management will enhance the lethality, survivability and capability of such a force, but that is the mid-term.

But without working the core concept of operations shifts, adding new machines will not have the impact they might have.

A good way to look at this dynamic is provided in the chapter by Harrison Schramm and Bryan Clark.

"A more disaggregated and reconfigurable force structure would enable a wider variety of potential force presentations. An AI-enabled control system could exploit the composability of a disaggregated force to create greater adaptability for the U.S. military and impose more dilemmas and complexity on an adversary, thereby increasing the opponent's uncertainty."

In my work with the Australian Defence Force and the recent Williams Foundation Seminar on Next Generation Autonomous Systems this is a key focus of attention for the ADF.

Reshaping the maritime force to operate as a fleet, and to do so in terms of blue water expeditionary operations is the foundation from which a transition to use effectively autonomous systems within which AI would play a decision guidance role is foundational.

There are several thoughtful chapters on C2 as the U.S. Navy turns its focus to peer warfare.

But as it does so there are three very important considerations which affect big data, AI and its use.

The first is that the peer competitors we are talking about are nuclear powers, so that any consideration of how to manage attacks upon peer adversaries must consider how those attacks affect the calculations of adversaries.

The second is that understanding of how adversaries think and how they might act is part of the calculation which AI processing of data can assist if we indeed have the knowledge to know what we are looking for and what we are looking at.

This is a huge gap as we turn from being Middle East experts to calibrating how authoritarian leaders in Russia and China under the global stress of COVID-19 and the post-globalization era looks like and how best to use military tool sets?

The third is the question of targeting.

There is a good treatment of the targeting or fires solution problem by Michael O'Gara.

He provides a cautious and careful assessment of how AI can help in the decision process to make a fires solution.

As he notes: "AI holds promise in handling resource priorities across domains more seamlessly while being capable of initiating responses based on more accurate and timely threat assessments."

But of course, the core targeting problem is not simply the speed to attack but also target selection in a crisis management setting.

But if confidence in both the speed and accuracy to attack is high and can be assisted by more rapid and effective data management and decision tools, then that can assist in providing for a wider set of crisis management options, from the standpoint of decision-making confidence as well.

The book does consider as well the problem of ability to spoof AI-enabled systems.

But there is as well the potential for distributed fleets to develop packages which they can deploy to deceive the adversary as well, even in terms of effective operating location.

The US Navy's Nemesis program is suggestive of such a possibility.

And in considering the future, it is important not to ignore the warfighting advantages our force already has that the adversary does not.

For example, the ability of an 8-ship F-35 formation to fight as a wolfpack, suggests what swarming could deliver in the midterm future.

The ability of U.S. and allied F-35s to operate over large areas like the North Atlantic and the Mid-Pacific to shape a COP and target identification has barely been scratched. These are harbingers of things to come, but they are here now.

The future is now.

The mid-term and long-term future are just that and mostly unknowable.

How well did the forecasters in 2019 do in forecasting 2020?

The book provides a very useful collection of essays which frame ways to think about AI, big data and C2 might change the future of warfare. It is well worth reading.

In a recently published Australian study on AI and the military, Peter Layton provided an interesting look at how to consider different ways AI-enabled assets might play out on future battlefields.

The conclusion to his study provides a very helpful and balanced look at the way ahead with regard to AI and warfare:

In the near-to-medium term, AI's principal attraction for military forces will be its ability to quickly identify patterns and detect items hidden within very large data troves. AI will make it much easier to detect, localise and identity objects across the battlespace. Hiding will become increasingly difficult.

However, the technology of contemporary AI has inherent problems. It is brittle, in being able to operate only in the context it has been trained for; it is unable to transfer knowledge gained in one task to another and it is dependent on data. Accordingly, AI when used in real-world situations needs to be teamed with humans. The strengths of AI can then counterbalance the weaknesses in human cognition and vice versa….

As a general-purpose technology, AI is becoming all-pervasive and will over time infuse most military equipment. Such ubiquity though means AI is likely to be initially employed within existing operational level thinking. In the short-to-medium term, it will enable the battlefield, not remake it.

In simple terms, AI's principal warfighting utility can be expressed as 'find and fool'. With its machine learning, AI is excellent at finding items hidden within a high-clutter background. In this role, AI is better than humans and tremendously faster. On the other hand, AI can be fooled through various means. AI's great finding capabilities lack robustness.

AI's 'find' abilities further provide mobile systems with a new level of autonomy, as the AI can analyse its surroundings to discern important operating data. This means that 'find and fool' tasks can be undertaken using in-motion and at-rest, AI-enabled systems featuring varying levels of autonomy. AI can bring to modern warfighting enhanced sensors, improved kinetic and non-kinetic kill systems, more convincing deception techniques and a wide array of ways to confuse. In this, it is crucial to remember that AI enlivens other technologies. AI is not a stand-alone actor, rather it works in combination with numerous other digital technologies, providing a form of cognition to these.

If being used for defensive tasks, a large number of low-cost IoT sensors using AI edge computing could be emplaced in the optimum land, sea, air, space and cyber locations in a territory in which an attacking force may move across. From these sensors, a deep understanding would be gained of the area's terrain, sea conditions, physical environment and local virtual milieu. Having this background data accelerates AI's detection of any movement of hostile military forces across it….

For Layton, the operational shift which AI-enabled warfare entailed could be understood as a shift from the kill chain to the kill web.

The kill chain model used by contemporary military forces tightly integrates the sense–decide–act logic flow. In contrast, the data flow across the large Internet of Things (IoT) field in the mosaic warfare construct creates a kill web, where the best path to achieve a task can be determined and used in near real-time. The use of the IoT field is then fluid and constantly varying, not a fixed data flow as the kill chain model implies. The outcome is that the mosaic warfare concept provides commanders with highly resilient networks of redundant nodes and multiple kill paths. Moreover, the mosaic concept aims to be scalable; the size and elements of the IoT field can be varied as battlefield circumstances demand.