Combined Joint Operations from the Sea Centre of Excellence

More Tools in the Toolbox: Increasing Resiliency Through Commercially Sourced Assets for Space Based Maritime Situational Awareness

Transforming Allied Maritime Potential Into Reality

This document was prepared by:
CAPT Todd Bonnar, MSC, RCN, Project Lead & Director

Please direct enquiries to:
Combined Joint Operations from the Sea Centre of Excellence
usff.cjos.coe@navy.mil or Phone: +1-757-836-2452

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1. EXECUTIVE SUMMARY

Inexpensive technology now enables even those with minimal resources to threaten the security of Alliance's nations with acts ranging from hybrid warfare, conventional warfare and even terrorism that have a high "return on investment."
It is without question that evolving threats and concepts of operations is driving the need for more and better ISR capabilities.

This Information Paper proposes that if NATO is to succeed in a race to master a "knowledge-based environment", it has to optimise maritime ISR in the Alliance, and in turn is compelled to consider the range of options available and add more tools to the ISR toolbox, including rapidly accessible, commercial options.

It is a generally accepted fact that great power competition has returned to the international relations environment, marked by Chinese and Russia competing to shape security architectures, as well as norms and practices worldwide. The tools of choice are no doubt policy driven from Beijing and Moscow but plausible deniability enables these malign activities to occur below the threshold of armed conflict and clouds efforts to assign attribution. These frictions will play out over decades, not only in Beijing, Washington, and Moscow, but in Africa and Europe, the Arctic, cyberspace and outer space.[1]

As they aim below the threshold of outright warfare, they do not necessitate or justify a warlike response, but rather a strategic communications and information campaign, built on aggregated domain situational awareness, designed to preserve and present truth and integrity in the world's court of public opinion.

In an attempt to achieve the required information advantage to counter these challenges, NATO has highlighted several initiatives in support of creating an all-domain sensing and sense-making capability through ISR. The aim of the future NATO Joint ISR enterprise is to gain access to data from multiple domains (space, air, land, sea, and cyber); make rapid sense of that data, securely deliver that data to weapons, weapon systems, and operational commanders; and maintain a deterrent effect in competition and decisive capability in combat, at a pace greater than the adversaries. Does it however, have the desired level of resiliency?

[1] https://www.wilsoncenter.org/issue/great-power-competition

In terms of force requirements, NATO will continue to ask the member states to strengthen their high-end capabilities quantitatively and qualitatively as well as to invest in cyber security and key enablers such as intelligence and reconnaissance, networked C4I, etc. The USN is countering multiple threat vectors (Russia, China, Iran, and North Korea). NATO's Maritime Enterprise draws on many of the same intelligence, surveillance, and reconnaissance (ISR) assets that support the current NATO Military Strategy and raises the question of that strategy's viability with reduced resources even outside its effectiveness. It is thus incumbent upon the Maritime Enterprise to look for ways to increase resiliency including rapidly accessible, commercial options.

The Russian vision includes destroying an adversary's ability to execute an offensive campaign" by achieving information superiority and functionally degrading their operations by eliminating their ability to effectively command and control their forces. "[2] This means Russia will target and attempt to quickly erode all the information NATO needs to orchestrate a successful campaign at Maximum Level of Effort such as intelligence, surveillance and reconnaissance, battle space management systems, and satellites. NATO requires an even basic redundancy in order to show resilience.

Data, a critical strategic, operational and tactical asset, is the underlying constituent to spawning the intelligence required to successfully support and execute NATO's three core missions. National security professionals from across the Alliance advocate that the ability to harness the power of aggregated data is fundamental to building and deploying the most effective military Alliance in the world and maintaining true deterrent effect. An inability to collect, analyze, and share data at a speed greater than NATO's competitors/potential adversary(s) will degrade situational awareness, command and control (decision making) and will negatively impact Allied forces.

[2] Ibid

The Alliance needs to develop a holistic vision for Big Data, enforce strict data protocols and develop and adapt to AI and machine learning in order to truly optimise its ISR capabilities. NATO as a whole must maintain its adaptability and agility in a highly competitive international environment with all nations collaborating in preparation for the transition to an AI-powered, highly interconnected world, because such a world will not tolerate weak links in defenses.[3]

"All the business of war, and indeed all the business of life, is to endeavour to find out what you don't know by what you do"

Arthur Wellesley
1st Duke of Wellington

2. INTRODUCTION

It is hard to get past headlines painting the portrait of a world besieged physically and economically by a medical crisis on a global scale and a nation that has turned the national spotlight onto the fundamentals of its constitutional democracy, including the persistence of racism, the right to protest, and the character of local and national security forces in the United States. Lost in this mass media reporting is a story worth a more detailed examination for it may portend a revolutionary change for modern naval warfare – advancing NATO's maritime situational awareness and understanding resiliency through commercially available space-based assets.

On Saturday 30 May 2020, SpaceX's Crew Dragon spacecraft carried NASA astronauts Doug Hurley and Bob Behnken into orbit for a rendezvous with the International Space Station. Of national significance was the fact that the Crew Dragon launched astronauts from US soil for the first time since the last Shuttle flight in 2011. The real point to note, however, is that the SpaceX Crew Dragon spacecraft is the first to be designed, built and launched to space by a private entity. That is an accomplishment only three nations — the U.S., Russia and China — have achieved previously. "A private company has just achieved a feat that heretofore has only been achieved by nation-states." As CNBC reported it, "The launch unlocks the possibility of a new era of sustained, private, commercial activity in space." [4]

[3] https://carnegieeurope.eu/2019/11/28/artificial-intelligence-and-future-of-conflict-pub-80421
[4] https://www.cnbc.com/2020/06/03/first-spacex-astronaut-launch-marks-crucial-leap-for-nasa-ambitions.html

A very natural extension of the significance of CNBC's statement is to ask, "what impact will commercialization have on space-based military applications such as Intelligence, Surveillance, Reconnaissance (ISR)". A celestial vantage point, as the ultimate high ground for overwatch, offers significant potential for satisfying a fundamental tenet of naval warfare - Maritime Situational Awareness (MSA). Having a clear picture and access to timely, relevant information is essential as it enables the early identification of potential threats and enhances appropriate responses.[5] Information superiority through high quality MSA enables naval warfare commanders at all levels – tactical through strategic – to get inside their adversaries' 'OODA Loop'.

The OODA loop was a tool developed by military strategist John Boyd to explain how individuals and organizations can win in uncertain and chaotic environments.[6] The ability to get inside your adversary's decision cycle of *Observe, Orient, Decide, Act* creates a Gordian Knot of threatening events and generates mismatches between what an adversary expects you to do and what you actually do. This makes your adversary feel trapped in an unpredictable world of doubt, mistrust, confusion, disorder, fear, panic, and chaos.[7] As former Commandant of the Marine Corps, General Charles C. Krulak stated in his analysis of the Gulf War: "The Iraqi army collapsed morally and intellectually under the onslaught of American and Coalition forces. John Boyd was an architect of that victory as surely as if he'd commanded a fighter wing or a maneuver division in the desert."[8]

When naval warfare operators think of ISR, for many, minds are often immediately drawn to modern day, advanced technological capabilities – low orbit earth observation or military communications satellites rapidly passing large data sets which ultimately result in operational outputs such as coordinated surface and subsurface TLAM strikes on shore-based targets or providing high resolution imagery to assist with ship and submarine movements. In reality, it is actually a system of systems that make up the space based ISR toolbox.

[5] https://navylive.dodlive.mil/2014/01/16/advancing-maritime-domain-awareness-mda-for-the-fleet-and-the-nation/
[6] https://taylorpearson.me/ooda-loop/#4_Tempo_You_Must_Get_Inside_Your_Adversarys_OODA_Loop
[7] Ibid.
[8] Ibid.

It is undeniable that NATO's joint maritime operations rely on space support provided by satellites, such as Satellite Communications (SATCOM), Position, Navigation, and Timing (PNT), and Intelligence, Surveillance, and Reconnaissance (ISR), as critical mission enablers. The services of ISR systems, in particular, have become more and more essential to NATO's decision-making and planning processes as the Alliance continues to project deterrence based on strength, readiness and speed of response with our Command and Control.

Some defense planners envision a future battlefield in which the ground is crawling with robots and the skies are darkened by drones. Swarms of unmanned systems would dominate in the battle for an ISR advantage. In reality, the issue of quantity versus quality when it comes to next-generation ISR is yet to be resolved. This is particularly the case in contested environments where targets are mobile or hidden, defenses have proliferated, a drone's guidance systems can be jammed, and networks compromised. In such a world, more sophisticated platforms deploying multiple sensors of greater range and acuity and carrying defensive and even offensive capabilities may make more sense.

It is widely agreed that as civilization entered the "Age of Information," but a couple of decades ago, militaries have seen ISR capabilities expanding in the air, land, maritime, space, and cyberspace domains, across what has been called 'today's knowledge-based environment'[9]. Although one could of course, easily argue that acting on knowledge is absolutely nothing new, it is also just as easy to argue that the complexity and the sheer volume of data and information management that indeed makes this the 'Age of Information". Thus, we now find the 'knowledge-based environment' in which today's modern navies must operate.

A recent study by the Netherlands based Clingendael Organization looking at the trends affecting the state of the Alliance in this Age of Information concluded that there are two main categorizations: structural challenges to NATO's own cohesion and the forecast on the Alliance's deterrence and defence posture by 2024.[10] In terms of force requirements NATO will continue to ask the member states to *strengthen their high-end capabilities quantitatively and qualitatively* as well as to invest in *cyber security and key enablers* such as intelligence and reconnaissance, networked C4I, etc. [11]

[9] Introduction to global integrated ISR, Annex 2-0 Global integrated intelligence, surveillance & reconnaissance operations, Curtis E. Lemay Centre, Jan 2015
[10] https://www.clingendael.org/pub/2018/strategic-monitor-2018-2019/the-future-of-nato/
[11] Ibid

If NATO is to succeed in the race to master this "knowledge-based environment", it has to optimise maritime ISR in the Alliance, and in turn, is compelled to consider the range of options available and add more tools to the ISR toolbox including resiliency through commercial applications. In a post COVID economy, this will be very difficult to accomplish with military acquisitions competing with much required social and economic impetus projects. Thus, NATO's nations absolutely need to look at more cost-effective options and models for acquisition and implementation.

However, each nation faces significant challenges with harnessing the exponential growth in data to realize the potential of disruptive technology and shaping future warfighting capabilities. Adding to the already complex and lengthy acquisition process, in a post COVID economy, major capital acquisitions will be very difficult to accomplish with national military acquisitions competing with much required social and economic impetus projects. Thus, NATO's nations absolutely need to look at more cost-effective options and models for rapid acquisition and implementation. The typical development and acquisition period for a new capability in a NATO nation is 16.5 years.[12] Resiliency must thus come in other forms.

"Traditionalists, who had been skeptical of new intelligence sources at the beginning of the conflict, became firm disciples for the remainder of the war."

Central Intelligence Agency Report circa WW2

3. HISTORY AND INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

Whilst the NATO Alliance was not formed until April 4, 1949, individual NATO countries were utilizing ISR to effect on the battlefields as far back as the late 1700s. In 1783 the French Montgolfier brothers conducted the first manned balloon flight on 21 November 1783.[13] Eleven years later, the French added the balloon to the combat arms toolbox during the French Revolutionary Wars. The French defeated the Austrian Army at the Battle of Fleurus in June 1794, in part, because they could see the enemy's troop movements from above. The gas-filled balloon *L'Entreprenant* hovered at 1,700 feet for over eight hours, delivering messages in bags with ballast on rings down the tether lines and via semaphore.[14]

[12] RADM John Tammen, ACT, SPP 16-6-20
[13] https://lemelson.mit.edu/resources/joseph-michael-and-jacques-etienne-montgolfier
[14] https://www.nationalmuseum.af.mil/Portals/7/documents/transcripts/isr_podcast_transcript_map.pdf

As the concept of flight progressed, so did the practical applications to ISR. After Wilbur Wright taught two Italian officers to fly in 1909, Italy was quick to adopt the use of fixed-wing aircraft in combat.[15] The Italians used airplanes (a Bleriot XI on 23 October 1911) to take reconnaissance photographs in Libya during the Italo-Turkish War of 1911 marking the first use of fixed wing ISR.

Before the modern era, national and strategic intelligence during the early stages of the Great War came primarily from espionage. With the introduction of aerial reconnaissance deep behind enemy lines, the expansion of the modern era toolbox would contribute to shaping strategy and assessing enemy intentions. In the face of unsustainable catastrophic casualties, military leadership and operational planners soon learned that planning and preparing for a land battle through in-depth study and analysis (aka *Observe & Orient* of the OODA loop process) would prove far more decisive than reliance on the simple élan that spurred the first waves of soldiers to rush forward into withering artillery and machine gun.[16]

The operational effect of good situational awareness is without question. British and French aviators made crucial reconnaissance observations that helped save tens of thousands of British troops from certain capture at Mons and win the First Battle of the Marne. However, one of the most difficult challenges was getting ground commanders to trust what the tools provided and believe in the intelligence.[17] By late 1915, intelligence information, especially that acquired from airplanes, had finally demonstrated that it was credible and contributed effectively to the conduct of battle. Traditionalists, who had been skeptical of new intelligence sources at the beginning of the conflict, became firm disciples of this new tool in the toolbox for the remainder of the war.

Some of the most impressive joint effects in the maritime came as a direct result of Joint ISR with the OA-10 Catalina the star performer of the most critical surveillance missions of World War II. It was a RAF Catalina that located the German battleship Bismarck, enabling the Royal Navy to destroy it in May 1941. A Canadian Catalina conducting ISR warned the Royal Navy's Indian Ocean fleet of the approach of a Japanese carrier group in April 1942. A US Catalina also

[15] Ibid
[16] https://encyclopedia.1914-1918-online.net/article/air_warfare
[17] https://encyclopedia.1914-1918-online.net/article/air_warfare

spotted the Japanese carrier force as it approached Midway Island in June 1942 and provided one of the most important radio messages of the war.[18]

During the Cold War, the strategic value of ISR provided by globe spanning satellite networks and supersonic manned spy planes, such as the U-2 and SR-71 Blackbird came to the forefront. On the 14th of October 1962, the pilot of an American U-2 spy plane making a high-altitude pass over Cuba, photographed a Soviet SS-4 medium-range ballistic missile being assembled for installation.[19] Then US President, John F Kennedy, decided to place a naval blockade around Cuba to prevent the Soviets from bringing in more military supplies and thus, enabled the US to force Soviet leader Nikita Khrushchev's offer to remove the Cuban missiles in exchange for the U.S. promising not to invade Cuba.

If history has taught us anything, it has shown that adapting to systems that provide access to jointly sourced, accurate and timely information is essential to gain advantage in battle. C2 came to depend on constantly collected intelligence from a rapidly expanding list of tools to support decisions from the planning stages to their execution. NATO would be wise to continue to heed these lessons learned as it deals with emerging threats in 2020 and beyond and add more tools to the toolbox.

"Many NATO nations are rethinking the process by which Maritime ISR is conducted and migrating away from a platform-based philosophy to a system-of-capabilities model for intelligence gathering."

Captain William A. Perkins
JAPCC

4. NATO AND INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

Joint ISR (JISR) remains a key capability allowing Allies to gain and maintain decision advantage in peacetime and crisis. The last 18 years of continuous conflict with multiple actors and terrorist organizations around the world has reinforced one consistent lesson to the Alliance: the importance of information, surveillance and reconnaissance (ISR) capabilities. Aligning efforts under NATO's JISR initiative, the Alliance's nations have made substantive gains in developing an array of agile, flexible and interoperable capabilities. The ability to Task, Collect,

[18] https://www.airspacemag.com/military-aviation/legends-of-an-ocean-crossing-seaplane-180971743/
[19] https://www.thenation.com/article/archive/october-14-1962-the-cuban-missile-crisis-begins/

Process, Exploit and Disseminate vast amounts of information from multiple types of sensors is vital to successfully prosecuting the adversary. Now, the Alliance is confronting new and evolving threats with the knowledge and, in a growing number of cases, the resources to counter current ISR capabilities.

NATO recognizes the strategic necessity of the further development of JISR capabilities. The Alliance currently fields a broad range of JISR capabilities that provide comprehensive situational awareness and decision support, and those capabilities can be reinforced by national capabilities as required.[20] The NATO Defence Planning Process (NDPP) aims to harmonize national defence planning efforts and prioritizes JISR as a strategic enabler in achieving NATO's level of ambition.

The events of 2014 marked a significant turning point for the Alliance. Russia's actions in the Ukraine and the illegal annexation of Crimea set in motion a series of discussions within NATO's top leadership about strengthening cooperation and ensuring tighter connections between the Allied forces. During the Wales Summit later that year, the Allied Heads of State and Governments expressed the ambition to provide NATO with an enduring and permanently available Joint ISR (JISR) capability, giving the Alliance the eyes and ears it needs to achieve strategic decision advantage over a resurgent Russia.[21]

In the event of crisis or conflict, NATO's nations, as members of a defensive military Alliance, in almost all cases would initially be reacting to an adversary who would control the preliminary timing or initiating actions. Analysis through wargaming and modelling and simulation, and combat experience have shown that blue (friendly) force attrition and asset requirements can be significantly reduced if an enemy can be engaged at the onset of aggression.[22] This is the reason rapid and persistent multi-domain awareness through ISR is so critical to NATO. It provides information and intelligence to key decision-makers, helping them make well-informed, timely and accurate decisions.

NATO's JISR project brings together data and information gathered through disparate yet inter-related projects such as NATO's Alliance Ground Surveillance (AGS) system or NATO AWACS surveillance aircraft as well as a wide variety of national JISR assets from the space, air,

[20] Admiral Mark E. Ferguson, 2019; retired as NAVEUR in 2016
[21] http://www.jwc.nato.int/images/stories/threeswords/NOV_JISR_Workshop.pdf
[22] https://www.tradoc.army.mil/Portals/14/Documents/MDO/TP525-3-1_30Nov2018.pdf

land and maritime domains. The Initial Operational Capability (IOC) for JISR, was declared in February 2016.[23] Both surveillance and reconnaissance include visual observation (from forces on the tactical battlefield) and electronic observation (for example from satellites, unmanned aircraft systems, ground sensors and maritime vessels), which are then analysed, turning information into intelligence.

Imagery Intelligence (IMINT), or the intelligence derived from imagery acquired by sensors be it ground based, sea borne or carried by air or space platforms, provides excellent operational data. It will often serve to support or confirm complimentary intelligence from other sources.

Often overlooked, Measurement and Signatures Intelligence (MASINT), or the intelligence produced by quantitative and qualitative analysis of physical attributes of targets and events to characterize, locate, and identify them [24] is derived from specialized, technical measurements of physical phenomenon inherent to an object or event where the measurement refers to actual measurements of parameters of an event or object. Early Warning operators and analysts have used this to great effect in developing detailed profiles of ballistic and tactical missiles, measuring electromagnetic pulse emissions associated with nuclear testing or other high energy events for the purpose of determining power levels, operating characteristics, and signatures of advanced technology weapons, power, and propulsion systems.[25]

MASINT consists of the following data sources:

a) Electro-Optical
b) Radar
c) Radio Frequency
d) Geophysical
e) Materials
f) Nuclear radiation

Signals Intelligence (SIGINT) is intelligence derived from the collection and exploitation of foreign electromagnetic signals or emissions. It is the generic term used to describe

[23] https://www.nato.int/cps/en/natohq/official_texts_127831.htm?selectedLocale=en
[24] https://usnwc.libguides.com/c.php?g=494120&p=3381426
[25] US Joint Publication 2-0

communications intelligence (COMINT) and electronic intelligence (ELINT) when there is no requirement to differentiate between these two types of intelligence, or to represent their fusion.

Geospatial Intelligence (GEOINT) is an intelligence discipline that has evolved from the integration of imagery, IMINT, and geospatial information to a broader cross-functional effort in support of national and defense missions and international arrangements. Advances in technology and the use of geospatial data throughout the joint force have created the ability to use geography by integrating more sophisticated capabilities for visualization, analysis, and dissemination of fused views of the OE. This capability provides many advantages for the warfighter, national security policy makers, homeland security personnel, and IC collaborators by precisely locating activities and objects, enabling safe navigation over air, land, and sea, assessing and discerning the meaning of events, and providing context for decision makers.[26]

A critical element of deterrence and defense, this networked system of sensors, collectors and analysts fielded by the Alliance and its member states, provides situational awareness, early warning and if necessary, decision support for combat operations. Put simply, NATO's JISR is about getting the right information to the right person, at the right time in the right format. The question is, is it resilient enough to withstand operations at Maximum Level of Effort?

The USN is countering multiple threat vectors (Russia, China, Iran, and North Korea). NATO's Maritime Enterprise draws on many of the same intelligence, surveillance, and reconnaissance (ISR) assets that support the current NATO Military Strategy and raises the question of that strategy's viability with reduced resources even outside its effectiveness. It is thus incumbent upon the Maritime Enterprise to look for ways to increase resiliency including rapidly accessible, commercial options.

"How do we get to the point where accelerated acquisition is not special? It's the way we operate, the way we do things."

William Bray
Deputy Assistant Secretary of the Navy

[26] Joint Publication 2-01

5. PRIVATE INDUSTRY INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

Our historical maritime forefathers such as Claudius Ptolemy, Ferdinand Magellan, Vasco de Gama and others who charted the globe would no doubt marvel at the geographic information available today. With technological advancements in small satellites, global information systems, aviation, digital photography, computer technology, and telecommunications, the market for high resolution satellite images and aerial photography is now accessible to virtually anyone and everyone.

Commercial technology in the year 2020 should present NATO with several opportunities to improve the time available to detect and react to a threat and to shorten the strategic and operational decision space as well as the "find, fix, track, target, engage and assess" (F2T2EA) process. In fact, a commercial satellite flying 488 miles above the Earth recently tracked and captured a Russian Navy missile launch in that took place in the Barents Sea, in Russia's arctic north.[27] An open-source intelligence analyst had been watching Russia's Northern Fleet closely over recent weeks. Racking up an impressive list of free satellite imagery, Mr. Frank Bottema, was able to know where to look for the missile test. Later that same day, the analysts, using the same imagery found a Russian submarine, the moment it surfaced.[28] Based on other intelligence, the submarine was identified as most likely being the BS-64 *Podmoskovye*, a Russian Navy spy submarine.[29]

Deterrence based solely on the strength of a response is no longer effective. Deterrence must be based on strength and speed of response. To achieve strategic and operational success for operations along the spectrum from deterrence to conflict, NATO must continue to invest in and leverage resilient and collaborative ISR capabilities that enhances situational awareness to effectively enable counter-operations in the grey zone and aid rapid decision-making, and reliably find, fix, and target elusive targets deep within enemy territory in highly contested environments whilst at Maximum Level of Effort (MLE). The objective is to generate an information advantage for NATO forces.

[27] https://www.forbes.com/sites/hisutton/2020/07/25/unusual-satellite-image-shows-arctic-missile-launch/#3ed3918f1223
[28] Ibid
[29] Ibid

As Deputy Assistant Secretary of the Navy for Research, Development, Test and Evaluation, William Bray stated “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.”[30]

There are currently eight different commercially supplied elements that NATO could look at to build resilient core construct of Space-based Global Maritime Awareness (GMA). This commercially supplied redundancy can increase resilience in ensuring ISR data to the various operational commands, enabling increased situational understanding and possibly targeting/cueing data needed to perform their mission within a highly contested environment, These current commercially sourced capabilities are:

a) Automatic Identification System (AIS)
b) Satellite AIS (S-AIS)
c) Radio Frequency Geo-Location Satellites
d) Synthetic Aperture Radar (SAR) Satellites
e) Optical Satellites
f) Earth Observation Systems
g) Support from dynamic data analysis supported by Artificial Intelligence & Machine Learning

Automatic Identification System

Since antiquity, navigators have determined their course and location by observing other objects on the ground and in the celestial sphere. This approach is vulnerable to adverse climatic/ambient conditions, however, as well as to limitations on the observer’s ability to track and interpret the characteristics of the target objects. Over time, the nature of sea transportation and operations has changed, as the size and speed of ships have increased, along with the sensitivity and value of their cargo. At the same time, the possibility of a significant disaster, and the damage caused by the increased size of vessels and the volume of traffic, has worsened. Our perception of the dangers of sea transportation and tolerance to impacts have also been changing. Loss of life and property at sea, which has been a problem for sailors and travelers, can be prevented by adopting cutting-edge technologies. AIS was originally developed as an aid to navigation. The maturity of this information technology and information application technology has created opportunities for broader application in many areas, including safety and accident

[30] http://cimsec.org/game-changing-unmanned-systems-for-naval-expeditionary-forces/35258

prevention, security, smart infrastructure and operations, transportation planning, cargo management, and the economy.[31]

Typically, the terrestrial AIS system has a range of 27-54 nautical miles (50-100 km), which limits any long-range ship position knowledge for agencies that need a wide area surveillance of ship positions and activity. Ships of 300 gross tonnage or more sailing on international voyages, cargo ships of 500 gross tonnage or more sailing in local waters, and all passenger ships irrespective of size are mandated by the International Maritime Organization (IMO) to carry AIS equipment. AIS transponders automatically broadcast information at regular intervals.[32] Navigational status data is transmitted every 2 to 180 seconds, depending on a vessel's activity. In addition, voyage related data is broadcast every 6 minutes. These signals are received by AIS transponders installed on other ships or by land-based systems.[33] Governments and maritime insurers rely on the Automatic Identification System (AIS) as a vital means for monitoring the oceans, but AIS has severe limitations. Ships engaged in illicit activities can deactivate their AIS beacons, vanishing off the map. Alternative options for monitoring, such a patrolling with coast guard vessels or airplanes, are resource intensive. The AIS signals have a horizontal range of about 40 nautical miles (74 km), meaning that AIS traffic information is only available around coastal zones or in a ship-to-ship zone.

The Vessel Identification System on the Columbus module of the International Space Station (ISS) has successfully monitored maritime traffic since 2010. This has been a successful testing of a system that has shown great improvements in monitoring global maritime traffic.

The current ground-based AIS specified by the International Maritime Organization is a ship-and-shore-based broadcast system designed to monitor maritime vessels only in coastal waters. The AIS for Columbus, known as the Vessel Identification System, operates in the very high-frequency (VHF) maritime band and greatly expands this capability. This AIS has been verified as a method of tracking global maritime traffic from space and incorporates maritime traffic in open waters. The autonomous system picks up signals from standard AIS transponders that are carried by all international ships over 300 gross tonnes on international voyages, cargo vessels over 500 gross tonnes that are not engaged on international voyages, and all types of passenger

[31] Focus on IMO: The New STCW Convention; International Maritime Organization: London, UK, 1997
[32] IMO. Regulations for Carriage of AIS. (I. M. Organization, Producer), AIS Transponders. 2019).
[33] IMO. Adoption of the Final Act and Any Instruments, Resolutions and Recommendations; Resulting from the Work of The Conference; Coast Guards: Washington, DC, USA, 2010.

ships mandated by the IMO to carry AIS transponders. The ISS's location at an altitude of 217 to 248 miles (350 to 400 km) is ideal for space based AIS signal reception and provides the means to be utilized by multiple users.[34]

Satellite Automatic Identification System

The probability of the detection of terrestrial AIS signals from space was presented in 2003, following the advancements in micro satellite technology. Through constant development, research and cooperation between governmental and private sectors, Satellite AIS (S-AIS) has been continuously evolving. Advancements in signal and data processing techniques have resulted in an improved detection over vast areas outside of terrestrial range. Some of the challenges of S-AIS technology include satellite revisit times, message collision and ship detection probability. Data processing latency and lacking the continuous real-time coverage made it less reliable for end user in certain aspects of monitoring and data analysis. Recent developments and improvements by leading S-AIS service providers have reduced latency issues. Complementing with terrestrial AIS and other technologies, near real-time S-AIS can further enhance all areas of the global maritime monitoring domain with emerging possibilities for maritime industry.[35]

SAT-AIS will make it possible to track seafaring vessels beyond coastal areas that are equipped with AIS tracking devices. SAT AIS is a solution to overcome terrestrial coverage limitations with the potential to provide AIS service for any given area on Earth. It is argued that space-based reception of AIS messages is a promising way of achieving long-range identification and tracking services at marginal cost.[36]

Radio Frequency Geo-Location Satellites

Space-based Global Maritime Awareness (GMA) came into being with the launch of the first S-AIS constellation by ORBCOMM in 2008 but it really was not complete as a system until the launch of unclassified radio frequency (RF) satellites in 2019. HawkEye 360's Pathfinder is probably the first RF geolocation satellite.[37] It has been recognized for some years that RF geolocation would be a very useful tool for maritime awareness, especially when used in collaboration with S-AIS. It fills a need to track ships when they turn off their AIS, as many bad

[34] https://www.nasa.gov/mission_pages/station/research/news/b4h-3rd/eo-tracking-global-marine-traffic
[35] (https://hrcak.srce.hr/213342)
[36] https://www.sciencedirect.com/science/article/abs/pii/S0094576506000233
[37] https://www.he360.com/new-hawkeye-360-radar-signals-delivers-comprehensive-maritime-awareness/

actors now do when they commence nefarious actions (potential grey zone activities), but one still requires AIS to identify the ships on initial contact, before they turn it off. These two systems, S-AIS and RF geo-location satellites are complementary, maybe even more synergistic than first envisioned.

RF geo-location satellites provide tools designed to answer questions that AIS alone cannot answer. For example, open-source material indicates the HawkEye Constellation can geolocate a diverse set of radio frequency (RF) signals emitted by warship ships such as marine radar, satellite communications, VHF radio, and emergency beacons. This broader RF range expands visibility to help locate AIS dark ships and identify anomalous behavior.

The constellation is comprised of a cluster of three satellites that fly in formation using a specially designed propulsion system. The low earth orbit and wide field of view of the satellites supports frequent revisit, on average as often as six hours. The company can program the onboard Software Defined Radios (SDR) to tune across most of the frequency range from 144 MHz to 15 GHz (approximately VHF to Ku-Band).

The use of machine learning and artificial intelligence to generate higher-order analytics, assists with revealing patterns of behavior about objects such as warships at sea. RF analytics helps fill critical knowledge gaps. But by fusing multi-source data sets, RF geo-location satellites can deliver deeper insights than previously commercially available. For example, an RF data layer enriches satellite imagery analysis, both guiding where to look and helping assess what is being viewed.

Synthetic Aperture Radar

Synthetic Aperture Radar (SAR) refers to a technique for producing fine-resolution images from a resolution-limited radar system. It requires that the radar be moving in a straight line, either on an airplane or orbiting in space. It is an active system with its own microwave illuminator. Its microwave operating frequencies are chosen so that the radar imaging is unaffected by weather or light (or the lack thereof). SAR is the only imaging system that can generate high resolution imagery, anytime, even in inclement weather or darkness.[38]

The basic principle of any imaging radar is to emit an electromagnetic signal (which travels at the speed of light) toward a surface and record the amount of signal that

[38] https://www.lockheedmartin.com/en-us/products/synthetic-aperture-radar.html

bounces/echoes back, or “backscatters,” and its time delay. The resulting radar imagery is built up from the strength and time delay of the returned signal, which depends primarily on the roughness and electrical conducting properties of the observed surface and its distance from the orbiting radar.[39]

SAR is a type of active data collection where a sensor produces its own energy and then records the amount of that energy reflected after interacting with the Earth. While optical imagery is like interpreting a photograph, SAR data requires a different way of thinking in that the signal is instead responsive to surface characteristics like structure and moisture.[40]

SAR creates imagery using radar, giving it different capabilities than traditional electro-optical satellite imagery. In addition to being able to produce images regardless of inclement weather or poor lighting conditions, SAR can provide data on material properties, moisture content, precise movements and elevation. Capella has previously stated that its satellites will be able to collect sub-0.5meter imagery, meaning it can be used to identify types of aircraft or vehicles at ground level. [41] Both USAF and USN have awarded commercial contracts to use its SAR for virtual reality software, missile defense and developing predictive intelligence to foresee foreign threats.[42]

Synthetic aperture radars collect data in the visible, near infrared, and short-wave infrared portions of the electromagnetic spectrum. Radar sensors utilize longer wavelengths at the centimeter to meter scale, which gives it special properties, such as the ability to see through clouds (view electromagnetic spectrum to the right). The different wavelengths of SAR are often referred to as bands, with letter designations such as X, C, L, and P.[43]

[39] ttps://nisar.jpl.nasa.gov/mission/get-to-know-sar/overview/
[40] https://earthdata.nasa.gov/learn/what-is-sar
[41] https://www.c4isrnet.com/battlefield-tech/space/2020/06/25/capella-space-will-share-synthetic-aperture-radar-imagery-with-nga/
[42] Ibid
[43] Ibid

It has now become increasingly common for Earth observation scientists to fuse both optical and SAR data sets into one analysis stream. However, the sheer volume of the almost non-stop influx of such data makes this a challenge to interpret. The advancements in cloud computing services, Artificial Intelligence (AI) and Machine Learning (ML) methods, however, are enabling an ever-increasing number of data sources to be exploited and analyzed in greater depth and detail in order to derive the unique insights to make even more informed decisions.[44]

Optical Satellites

Opto-electronic satellites can be considered to be passive. They examine the surface of the Earth across a varied spectrum of electromagnetic radiation frequency, especially at wavelengths typical for visible light or for infra-red.[45] The demand for real time or near real time visual identification and tracking of targets drove the development of ever more compact, higher resolution video cameras placed in orbit. As new technologies became available, technicians added sensors operating in other portions of the electro-magnetic spectrum creating a capability for multi-spectral ISR. These “bolt on" sensors function in the optical part of wavelength spectrum, and include visible, near infrared and short-wave infrared wavelengths. The satellites in question make use of the fact that some of the sunlight, that is not absorbed on the surface of the Earth, is reflected back into space. They may only capture images of good quality if the weather and the sun permit.

The trend of the civilian customer-market driving innovation and technological breakthrough will continue, making access to new technologies easier than before.[46] In the near future, forward deployed maritime forces will need to be augmented by unmanned tools such as space based ISR as they contest adversaries in traditional and non-linear battlespaces and as such, the Alliance, should consider the range of options available and add more tools to the ISR toolbox, including rapidly accessible, commercial options.

[44] https://earthi.space/blog/radar-vs-optical-earth-observation-why-both/
[45] https://www.defence24.com/optics-or-radars-what-is-better-for-the-earth-observation-purposes
[46] https://www.clingendael.org/pub/2018/strategic-monitor-2018-2019/the-future-of-nato/

"Only with support from space will it be possible for the Armed Forces to reach maximum effectiveness...Our Army and Navy must not only meet the requirements of today but be prepared for tomorrow's means of conducting armed struggle. The solution of this problem doubtlessly depends directly on the availability of modern orbital constellation of military satellites"

Sergei Shoygu
Russian Defence Minister

6. THE ADVERSARY INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

In today's security environment, uncertainty will increase with respect to who, where, when, and how NATO military forces may be called upon to fight. Inexpensive technology now enables even those with minimal resources to threaten the security of Alliance's nations and with acts ranging from hybrid warfare, conventional warfare and even terrorism that have a high "return on investment."

It is without question that evolving threats and concepts of operations is driving the need for more and better ISR capabilities. More technological advances are likely to occur in the next 5 years than have occurred in the preceding 25 years (from the time when the World Wide Web was adopted as common usage). Most of these advances, on which the Nations and Navies will have to capitalize, will come from the commercial sector, presenting a two faceted dilemma for NATO. Firstly, as with most technological advancements, it will be a difficult challenge for the current procurement process of most NATO nations to keep current through organic development of ISR assets. The current procurement process for NATO nations concentrates on buying large capital projects - ships, airplanes, tanks, and their spares and training requirements. Most of these items have lives that are measured in decades, with a few major upgrades over their lifetime. Information technology is changing on the timeline articulated in something known as Moore's Law and does not fit into such a process.

Secondly, as was described above, high end ISR capabilities and products that were formally the sole domain of militaries of technologically advanced nation states, are now readily available on the commercial market. This means that over time, owing to Moore's Law, entry costs into this market will continue to drop.

Gordon Moore, the cofounder of Intel, made a very telling observation in 1965 (which went on to be known as Moore's Law), that the number of transistors per square inch on integrated circuits had doubled every year since the integrated circuit was invented.[47] This foresight laid a fertile foundation from which all modern technology could spring, including the broad rise of digitization. He extrapolated that computing would dramatically increase in power, and decrease in relative cost, at an exponential pace. The insight, known as Moore's Law, became the golden rule for the electronics industry, and a springboard for innovation. Moore predicted that this trend would continue for the foreseeable future. In subsequent years, the pace slowed down a bit, but since then, data density has doubled approximately every 18 months. Most experts, including Moore himself, expect Moore's law to hold for at least another two decades.[48] It is very foreseeable that in the near future, the free market system will enable some lesser state and/or non-state actors (I.e. ISIS, Al-Qaeda, etc.) to have the option to commercially acquire their own ISR for operational planning and the conduct of lower-end fights.

On June 28, 2005, Google announced the launch of Google Earth, a satellite imagery-based mapping product that intertwines three-dimensional urban build up with terrain with mapping capability. Since the introduction of Google Earth, a decade and a half ago, it has become remarkably simple for our adversaries to find and use online satellite and aerial imagery services for nefarious purposes, including combat.[49] In January 2007, terrorists attacked British bases in Basra, Iraq, using aerial footage displayed by Google Earth to pinpoint their attacks, according to United Kingdom army intelligence sources.[50] The possibility now exists that terrorists and insurgents could use much more sophisticated and detailed commercial intelligence products to plan attacks within the nations of the Alliance.

It is already starting to happen with other easy entry technology such as drones. Drones can be employed by terrorists and insurgents for intelligence, surveillance, and reconnaissance missions, or they can be weaponized. In Yemen, Houthi rebels used unmanned aerial systems to attack Saudi Arabian air defenses. Hezbollah, arguably one of the world's most advanced terrorist organizations, has used drones against the ISIS in Syria. The Islamic State used a drone to drop grenades on an adversary's military base. And in early January 2019,

[47] https://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html
[48] Ibid
[49] https://law.und.edu/_files/docs/ndlr/pdf/issues/83/2/83ndlr547.pdf
[50] Ibid

Turkish-backed rebels used drones to conduct 'swarming' attacks on two Russian bases in Syria.[51]

Looking at ISR through a near peer aperture of Russia, they see NATO's ISR as a prime target in their "system of systems" approach to conflict. This system's approach, not that dissimilar to an effects-based approach to operations, includes destroying an adversary's ability to execute an offensive campaign by "achieving information superiority and functionally degrading their operations by eliminating their ability to effectively command and control their forces." [52] Russia has established and anti-space force (the *Protiv Kosmositchiski Oborny* (PKO) and have developed a concept they call *Radio Electronajika Borba* (REB) to counter NATO's C4ISR.[53]

In a recent speech General Valery Gerasimov, Russia's Chief of General Staff, stated, "The basis of 'our response' is the 'active defense strategy,' which, given the defensive nature of the Russian Military Doctrine, provides for a set of measures to proactively neutralize threats to the security of the state."[54] In this context, he emphasized initiative and pre-emption, adding, "We must act quickly so as to pre-empt the enemy with our preventive measures, promptly identify his vulnerabilities, and create threats of unacceptable damage to it. This ensures that the strategic initiative is captured and maintained."[55]

This Russian vision includes destroying an adversary's ability to execute such an offensive campaign" by achieving information superiority and functionally degrading their operations by eliminating their ability to effectively command and control their forces. "[56] This means Russia will target and attempt to quickly erode all the information NATO needs to orchestrate a successful campaign at Maximum Level of Effort such as intelligence, surveillance and reconnaissance, battle space management systems, and satellites. NATO requires an even basic redundancy in order to show resilience.

[51] https://thesoufancenter.org/intelbrief-terrorists-use-of-drones-and-other-emerging-technologies/
[52] https://warontherocks.com/2019/09/its-time-to-talk-about-a2-ad-rethinking-the-russian-military-challenge/
[53] https://icds.ee/wp-content/uploads/2018/ICDS_Report_Russias_Electronic_Warfare_to_2025.pdf
[54] Ibid
[55] Ibid
[56] Ibid

China employs a robust space based ISR capability designed to enhance its worldwide situational awareness. Used for military and civil remote sensing and mapping, terrestrial and maritime surveillance, and military intelligence collection, China's ISR satellites are capable of providing electro-optical and synthetic aperture radar (SAR) imagery, as well as electronic intelligence and signals intelligence data. [57]

China produces its military-dedicated satellites domestically and its civil communications satellites incorporate off-the-shelf commercially manufactured components. China is testing multiple next-generation capabilities, such as quantum-enabled communications, which could supply the means to field highly secure communications systems.[58]

"To start a war without controlling the electromagnetic spectrum is tantamount to defeat"

Colonel (RET) Anatoly Tsyganok
Russian Center for Political-Military Studies

7. CHALLENGES WITH INTELLIGENCE, SURVEILLANCE, AND RECONNAISSANCE

It is not the position of this paper to suggest that NATO simply runs out and immediately signs contracts with the various space based ISR vendors. The main argument being made is that demonstrating deterrence requires the ability to demonstrate resilience to the point where adversaries feel a lack of comparative advantage in a specific capability means "the reward is not with the risk".

To take advantage of the enormous benefits offered by both commercially acquired and organically gleaned space based ISR, a global network-centric naval communications and processing network architecture is needed for NATO's maritime domain—an architecture driven by the doctrine and overarching information architecture of a "come as you are" rapid force application. The critical common denominator with these space based ISR systems feeding this information architecture is the data that each sensor collects and how it is aggregated to present much greater situational awareness or even situational understanding.

[57] Challenges to Security in Space, DIA www.dia.mil/Military-Power-Publications
[58] Ibid

Data, a critical strategic, operational and tactical asset, is the underlying constituent to spawning the intelligence required to successfully support and execute NATO's three core missions. National security professionals from across the Alliance advocate that the ability to harness the power of aggregated data is fundamental to building and deploying the most effective military Alliance in the world and maintaining true deterrent effect. An inability to collect, analyze, and share data at a speed greater than NATO's competitors/potential adversary(s) will degrade situational awareness, command and control (decision making) and will negatively impact Allied forces.

It goes without saying that numerous challenges exist for JISR to successfully operate within a highly contested maritime environment even with an overarching information architecture. However, NATO could face significant challenges with harnessing the power of this aggregated data and making sense of what has been collected even in Baseline Activities and Current Operations. For example, networks, platforms, sensors, and military personnel must be able to penetrate adversary defenses, collect data, analyze that data and recognize threats and targets, and ultimately share that data with decisionmakers, other sensors, and weapons, at machine-speed. Despite the JISR program, there are also known issues with a lack of standing data collection operations and further barriers posed by information sharing caveats and restrictions by various Alliance nations or even between entities within the NATO Command Structure.

Intelligence analysts are contending with having access to too much data, which can have a debilitating effect when attempting to discover high-value data in order to generate insights, especially rapidly. It is this challenge that has led DOD toward developing disruptive technology, such as AI/ML, that allows for human-machine teaming to ultimately help analysts make sense of the tidal wave of data. All domain ISR modernization will cover a "range of capabilities" by incorporating new AI/ML tools and using new intelligence sources, to include publicly available information

Before NATO begins to address these operational challenges, it could be argued that there are three foundational hurdles that must first be overcome to truly make commercially acquired space based ISR an option:

i.) **The Lack of a NATO Capstone Big Data Strategy**. Building a data strategy for the Alliance provides the framework for exploiting data as the trend moves toward future warfare with artificial intelligence, autonomy, robotics, etc. While STANAGs are in place on how to store and tag data, the real issue is whether these standards are being enforced. If data is not stored properly nor in a manner for proper use, then the Alliance is not farther ahead in meeting machine learning goals. In not providing a data strategy now, steps are skipped that will lead to larger consequences in the future. Data is a strategic asset with a subjective value that NATO's competitors will continue to interfere with. Now is the time to create the strategies that are needed to support future warfare. [59]

ii.) **Data Formats Leading to Limitations in Data Discovery**. Any solution to challenges in achieving interoperability will require addressing both organizational and technical issues. Despite the large number of organizations involved in addressing interoperability, there continues to be significant issues, even across releases of a single system. The implementation of systems capable of working together and a common data standard improves both response time and situational awareness. Automatic information processing and increased understanding and response of specialised personnel can be decisive factors that increase the pace of decision-making processes. Using standard data formats can help operators rapidly identify and access current threats and determine the necessary course of action. [60]

iii.) **Contending with the Sheer Abundance of Data Generated Across the Globe**. As pointed out by Carnegie Europe in their study of future conflict, in any future wars or even within a future environment of competition, victories and deterrence, will increasingly depend on the systematic synchronization of the physical, informational, and cognitive battlefields, all augmented by algorithmic warfare.[61] However, in the interim, the issue of data saturation is very significant. The rapid rise in NATO's ability to collect data hasn't been matched by the Alliance's ability to support, filter and manage the data. Experts have indicated that this "*info-obesity,*" or

[59] LCdr Jay Huls, *Call for Big Data Strategy,* Combined Joint Operations from the Sea Centre of Excellence
[60] CDR Neculai Grigore, *Naval Operations – Cyber Interoperability*, Combined Joint Operations from the Sea Centre of Excellence
[61] https://carnegieeurope.eu/2019/11/28/artificial-intelligence-and-future-of-conflict-pub-80421

the attempt to gorge on an inconsumable amount of data that is not just unwieldy but can become dysfunctional. [62]

The Alliance needs to develop a holistic vision for Big Data, enforce strict data protocols and develop and adapt to AI and machine learning in order to truly optimise its ISR capabilities. NATO as a whole must maintain its adaptability and agility in a highly competitive international environment with all nations collaborating in preparation for the transition to an AI-powered, highly interconnected world, because such a world will not tolerate weak links in defenses.[63]

The history of failure in war can be summed up in two words – Too Late. Too late in comprehending the deadly purpose of a potential enemy; too late in realising mortal danger; too late in preparedness; too late in uniting all possible forces for resistance; too late in standing with one's friends.

General Douglas MacArthur, 1941

8. CONCLUSION

Since the end of the Cold War, Russia has sought to sustain its atrophying ISR and remote sensing satellite fleet, despite funding shortfalls, economic sanctions, and technological setbacks. Longstanding technological and cost barriers to space are falling, enabling more countries and commercial firms to participate in satellite construction, space launch, space exploration, and human spaceflight. Both Moscow and Beijing have indicated that they view space as important to modern warfare and view counterspace capabilities as a means to reduce potential adversaries', such as the U.S. and NATO, military effectiveness.[64] Both reorganized both their militaries' force structures and operational doctrines, emphasizing the importance of space operations. Likewise, Iran and North Korea also pose a challenge to militaries using space-enabled services, as each has demonstrated jamming capabilities. Iran and North Korea maintain independent space launch capabilities, which can serve as avenues for testing ballistic missile technologies. It is imperative that NATO, now more than ever, must take steps to maintain resiliency in operations, especially ISR.

[62] https://www.forbes.com/sites/kimberlywhitler/2018/03/17/why-too-much-data-is-a-problem-and-how-to-prevent-it/#3493ee06755f
[63] https://carnegieeurope.eu/2019/11/28/artificial-intelligence-and-future-of-conflict-pub-80421
[64] Challenges to Security in Space, DIA www.dia.mil/Military-Power-Publications

ISR is a military operation intended to help "decision makers anticipate change, mitigate risk, and shape outcomes." [65] The Alliance must demonstrate strength and speed of response in both the traditional domains and non-linear battle spaces, such as space, cyber and the information domains as deterrence based solely on the strength of a response is no longer effective. Deterrence must be based on cognitive superiority. In terms of capabilities the NATO call will be to develop further "an array of robust, sophisticated, and evolving capabilities across all domains, including heavier, more high-end, fully supported and deployable, sustainable, and interoperable forces and capabilities that are held at high readiness to perform the whole range of Allied tasks and missions."[66]

If the NATO Maritime Enterprise is to succeed in the race to master this "knowledge-based environment", it has to lead efforts to optimise maritime ISR in the both the NATO Command Structure and the NATO Force Structure. In turn, it is compelled to consider the range of options available and add more tools to the ISR toolbox, including rapidly accessible, commercial options to increase resiliency.

The trend of the civilian customer-market driving innovation and technological breakthrough will continue, making access to new technologies easier than before.[67] To take advantage of the enormous benefits offered by network centric capabilities, a global network-centric naval communications and processing network architecture is needed for NATO's maritime domain—an architecture driven by the doctrine and overarching information architecture of the "come as you are" rapid force application. In the near future, these forward deployed forces will need to be augmented by unmanned tools such as space based ISR as they contest adversaries in this non-linear battlespace.

NATO's ISR architecture for future naval strike groups should exploit communications and information-management capabilities, employ shortened and more effective command-and-control (C2) chain, access ISR capabilities provided by national and joint systems, and provide the ability to establish interoperability. ISR in the maritime domain is an enabler of MSA and of the full spectrum of maritime activities. As such, NATO MISR assets should be interoperable and readily available to be integrated in a coalition force. Critical capability shortfalls should be mitigated with the development and procurement of new platforms, sensors and systems taking

[65] Congressional Research Service, Report to Congress on Intelligence, Surveillance and Reconnaissance for Great Power Competition, 4 July 2020
[66] https://www.clingendael.org/pub/2018/strategic-monitor-2018-2019/the-future-of-nato/
[67] Ibid

advantage of new and emerging technologies as the Joint Airpower Competence Centre states in their *Enabling Maritime ISR through the 'Family of Systems',* NATO needs to modify its collective aperture to the perspective on ISR that changes from a platform-centric view to one based on capabilities spread over multiple platforms.[68] This is a deliberate approach to better consolidate strategic ISR collection capabilities with those focused on the operational and tactical levels, as well as to integrate those platforms that can only perform some of the kill chain functions with those able to execute the remainder. The key to this family concept is interoperability and integration; the ability to share information.[69]

The current procurement process for NATO nations concentrates on major capital acquisitions - buying ships, airplanes, tanks, and so on. Most of these items have lives that are measured in decades, with few major upgrades over their lifetime. Information technology is changing on an exponentially shorter timeline and does not fit into such a process. In a post COVID environment where national economies will be recovering for years, this will be very difficult to accomplish as resources dedicated to military acquisitions will be prioritised and thus, competing with much required social and economic impetus projects. Thus, it is thus incumbent upon the Maritime Enterprise to look for ways to increase resiliency including integrating rapidly accessible, commercial options into the ISR toolbox.

[68] https://www.japcc.org/enabling-maritime-isr-through-the-family-of-systems/
[69] Ibid.