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Air and Space Power in Counter-Piracy Operations

Joint Air Power Competence Centre

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FROM:
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SUBJECT:
Air and Space Power in Counter-Piracy Operations

DISTRIBUTION:
All NATO and EU Nations and Relevant Organisations

Somali piracy is a local problem with regional reach and global impact. The overall international community response based on a comprehensive and cross-sector approach has been, to a certain extent, successful but not decisive in the short term. While international organisations' initiatives continue ashore for increased governance and capacity building, simultaneous, correlated and effective military law enforcement contribution is needed. With Operation OCEAN SHIELD, NATO has been contributing military forces, mostly surface assets, to the Counter-Piracy endeavour, operating in coordination with EU, multinational and single nation Task Forces.

In general, warships are the natural end-to-end capability to counter piracy but their effectiveness is highly influenced by the vastness of the area of operations and the intrinsic characteristics of the 'enemy'. The military use of Air and Space (A&S) would provide persistence, penetration and ubiquity over the Counter-Piracy region, ensuring the necessary wide area surveillance capability and matching the requirements dictated by the operational environment.

This document provides a general understanding of the principal means whereby A&S Power can support the NATO Counter-Piracy mission. It is therefore designed to define the best composition of capabilities for the most efficient and effective Intelligence, Surveillance and Reconnaissance support to maritime forces in combating piracy. To achieve this aim, the JAPCC addressed the issue via a scientific and empirical approach based on an experiment executed by the Boeing Portal, a Boeing Defence UK Ltd asset specialised in advanced modelling, simulation and analysis.

Please feel free to contact my Combat Air Branch at JAPCC via e-mail: ca@japcc.de or phone: +49 (0) 2824 90 2222 or 2221. We welcome your comments on our document or any future issues it identifies.

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PREFACE

Background

NATO has been contributing military forces, mostly warships, to the Counter-Piracy (CP) mission off the Horn of Africa (HoA) since October 2008. Commanders at sea have made several strong appeals for more Air and Space (A&S) assets, namely, Maritime Patrol Aircraft (MPA), Airborne Warning and Command System (AWACS) and UAS Systems stating that A&S assets are required to ensure rapid reaction capabilities and to enhance situational awareness. A limited number of assets have been operating under the European Union (EU) Flag (Operation ATALANTA), and the US-led Combined Maritime Force (CMF). Other than organic helicopters aboard warships, NATO only recently contributed air assets to its own mission, Operation OCEAN SHIELD (OOS), but in limited numbers and with intermittent deployments.

This low weight of effort is likely to persist. However, if the effects of piracy were to become more severe in terms of economics and safety for seafarers, the priority of the CP mission would likely rise and the Alliance may resolve to deploy A&S assets. As such, NATO nations must be prepared to deploy and employ the most effective and efficient mixture of A&S forces.

Aim

The aim is to provide an insight into the A&S Power contribution to CP operations off the HoA by determining the optimum use of A&S assets in the CP mission.

Specifically, as a preparedness prerequisite for the deployment and employment of NATO A&S assets for CP, this document attempts to fill the need to define the best composition of capabilities for the most efficient and effective Intelligence, Surveillance and Reconnaissance (ISR) support to maritime forces.

As a secondary objective, this document also seeks to extract best-practice concepts for the enhancement of regional Maritime Domain Awareness.

To achieve the aims, the JAPCC addressed the CP issue via a scientific and empirical approach based on an experiment executed by the Boeing Portal, a Boeing Defence UK Ltd asset specialised in advanced modelling, simulation and analysis.

Purpose

Naval operations have increasingly gained relevance in the law enforcement actions against piracy. This paper considers the positive influence that A&S Power can produce in the overall effort to disrupt piracy. It also sets the objective by providing the necessary background information to prepare the Alliance with a detailed plan for ISR A&S support to CP off the HoA, which could also be set as a model for the enhancement of NATO's understanding of how to most effectively and efficiently employ A&S assets in support of other Maritime Security Operations (MSO).

Application

In general, this document is designed to be a readily-accessible reference for use by those personnel with responsibility for or interest in the application of A&S Power in CP operations.

Being based on the results of an experiment, this document is not intended to provide authoritative or definitive advice, nor is it a substitute for relevant doctrine, policy or reference documents.

Primary stakeholders for this paper are those headquarters running or participating and leading CP operations and those nations providing or able to provide A&S assets.

Dissemination will be assured to all NATO/EU/national headquarters and agencies engaged in the mission against piracy.

Assumptions and Limitations

- Piracy will not be entirely eliminated in the short term, even by kinetic action ashore;

- NATO will not terminate Operation OCEAN SHIELD in the short term;

- The study is limited in scope to the A&S support to CP operations under the current limitations of OOS, meaning operations at sea and excluding engagement operations ashore from the air;

- This paper does not include a comprehensive approach on the Piracy issue, but is rather a part of it;

- To avoid duplications of existing documents and redundancy, all information on piracy and CP operations in this paper are to be considered the framework of the analysis of A&S Power contribution to CP;

- The research and the experimentation do not address the full range of A&S Power capabilities in support of CP operations, rather it mainly refers to air and space based ISR capabilities.

Authority

This paper is the result of JAPCC Subject Matter Experts (SMEs) study and research led by JAPCC Combat Air Branch. It also includes information contained in an experiment report produced by The Boeing Portal. The experiment was designed by JAPCC and the Boeing Portal under cooperation guidelines.

Classification

This document has been compiled by retrieving open source information. It therefore carries no security classification and is releasable to the public.

Reference to classified sources may be required to support more detailed analysis and formulate recommendations that go beyond the information and the findings presented here.

Acknowledgements

The JAPCC gratefully acknowledges all those individuals responding to requests for support and data provision in producing this document. Special appreciation goes to The Boeing Portal[1] team for the enthusiasm, candour and expertise shown in the experimentation process, which proved to be vital for the accomplishment of the aim of this paper.

Overview

This document provides a general understanding on the principal means whereby NATO CP operations could be supported by A&S Power. In order to offer a self-contained reference source, it sets out the piracy threat as it exists in the current time frame and considers the effort sustained by the international community. Specific focus is then provided on current and near-term future capabilities and processes that, if made available to NATO, could deliver effectiveness in the attempt to counter piracy. In discussing the specifics of A&S Power contribution, it utilises an experimental approach aimed at determining the right mix of forces, by empirically measuring the proficiency of different combinations. The paper concludes with a series of recommendations derived both from the experiment results and JAPCC SMEs research.

1. The Boeing Portal is Boeing Defence UK's (BDUK) state-of-the art facility that uses advanced technologies to support customers' needs to explore and understand requirements in both the defence and security domains. It provides the environment to conduct experimentation to analyse all aspects of military and security related operations. The centre can be used to compare the effectiveness and survivability of competing systems, to test future scenarios, and to assess potential solutions before they are delivered to the user community.

Somali women and children line up to receive food distributed by Jumbo organisation, a local Non-Governmental Organisation (NGO), after fleeing from southern Somalia.

CHAPTER 1

Somali Piracy

1.1 Introduction

1.1.1 In Somalia, poverty and unemployment are predominant. The World Bank estimates that over 40 per cent of Somalis live in extreme poverty (less than a dollar a day) and almost 75 per cent of households exist on less than $2 a day. Approximately two-thirds of Somali youth are without jobs. A combination of inter-clan rivalry, corruption, arms proliferation, extremism and pervasive impunity has facilitated crime in most parts of Somalia, particularly in Puntland and Central Somalia. This criminal activity eventually moved from the land to the sea, resulting in a dramatic increase of piracy activities in the region.

1.1.2 Initiatives and efforts to tackle the problem are finally providing encouraging results. In 2011, there was nearly a 42 % decrease in *successful* pirate attacks due to the effort and action of military naval forces (with a more assertive posture both in disrupting attacks and in freeing hijacked vessels) and preventive/responsive measures used by the merchant vessels. Nevertheless, the number of *attempted* attacks is still growing. Moreover, in the last 4 years there has been an increase in the level of violence and the use of weapons by pirates.

1.1.3 The highest risk for the international community is the potential for piracy to transform into something more daring and violent. Also, piracy could be used as an operational/tactical model for other criminal activities such as terrorism. The employment of skiffs as sea-based Improvised Explosive Devices is plausible

On 02 December 2008 the United Nations Security Council adopted Resolution 1846 extending the mandate for states to fight Somali pirates and urging the UN to play a coordinating role in the endeavour.

and this risk might be multiplied by the concurrency of piracy activities. This scenario, which would be outside of the CP mandate, would require the international community to deal with far more violence, energy security issues, economic consequences and environmental disasters.

1.2 International Community Response

1.2.1 The United Nations Security Council (UNSC) has issued a series of resolutions to facilitate an international response, which is coordinated by a multilateral Contact Group. The Council has authorised international navies to counter piracy both in Somali territorial waters and ashore, with the consent of Somalia's Transitional Federal Government (TFG). It also authorised, as an exemption to the United Nations (UN) arms embargo on Somalia, support for the TFG security forces.

1.2.2 The international community has answered the UN call by undertaking an array of initiatives to prevent and deter pirate attacks. Various authorities have implemented information/warning systems to vessels sailing in the waters off the HoA and continue to provide guidance on measures to maximise safe navigation in pirate infested waters.

1.2.3 The shipping industry, in coordination with the combined naval forces conducting CP operations, has produced guidance, known as Best Management Practices (BMP), for mariners transiting in high risk areas. In addition, most shipping companies now equip vessels with self-defence measures, such as barbed wire, water cannons, citadels (safe quarters for crews) and, recently, with armed security guards (contractors or military).

1.2.4 On the military side, the international effort has been quite substantial, as never before seen in recent Maritime Security Operations (MSO).

Since 2008, the European Union has been conducting Operation ATALANTA with the European Naval Force (EUNAVFOR), in support of UN Security Council Resolution 1846 in order to contribute to:

- the protection of vessels of the World Food Programme (WFP) delivering food aid to displaced persons in Somalia;
- the protection of vulnerable vessels cruising off the Somali coast, and
- the deterrence, prevention and repression of acts of piracy and armed robbery off the Somali coast.

29 November 2011 – ITS Andrea Doria assists the MV Rosalia D'Amato after she was released from 7 months in pirate captivity.

Operation ATALANTA is the first EU maritime operation, and it is being conducted under the framework of the Common Security and Defence Policy (CSDP).

On 23 March 2012, the EU Council extended the force's area of operations to include Somali coastal territory as well as its territorial and internal waters in order to enable Operation ATALANTA to work directly with the TFG and other Somali entities to support their fight against piracy in the littorals.

This decision also provides the authority to extend the EU CP mission beyond vessel escort duties and counter-piracy manoeuvres off the coast of Somalia to include operations against the pirates' shore-based assets.

Operation OCEAN SHIELD, NATO's contribution to international efforts to combat piracy off the HoA, commenced 17 August 2009 after the North Atlantic Council (NAC) approved the mission. OOS builds on the experience gained during Operation ALLIED PROTECTOR, NATOs' previous CP mission, and develops a distinctive NATO role based on the broad strength of the Alliance by adopting a more comprehensive approach to CP efforts.

Somali pirate skiff.

The Horn of Africa map.

Naval CP operations are the focus under the umbrella of UN Resolutions to deter, defend against and disrupt pirate activities.

U.S. Naval Forces Central Command (NAVCENT) commands the Combined Maritime Forces (CMF) operating in the Arabian/Persian Gulf, Gulf of Oman, Gulf of Aden, Red Sea, Arabian Sea, and Indian Ocean. In January 2009, the command established Combined Task Force 151 (CTF-151), with the sole mission of conducting anti-piracy operations in the Gulf of Aden and the waters off the Somali coast in the Indian Ocean. The list of countries participating in CTF-151 is fluid and consists of personnel but typically ships from 25 countries.

Non-Alliance countries, most notably Russia, China, and India, have deployed naval forces to the region to participate in monitoring and anti-piracy 'national escort system' operations.

1.3 Pirates' Profile

1.3.1 Initially organised predominantly along clan lines and based in remote port towns, pirate groups have varying capabilities and patterns of operation, making generalised responses more difficult. Reports suggest that there may currently be 7 to 10 distinct gangs financed by so-called 'instigators' who organise funding and delegate operations to group leaders.

1.3.2 Most pirates are aged 20–35 years old and are generally former local fishermen, or ex-militiamen who used to fight for the local clan warlords. Their primary motivation is profit as a way out of poverty.

1.3.3 Reports indicate that ransom earnings have been invested in upgraded weaponry and the fortification of pirate's operating bases against local authorities or potential international military intervention onto land.

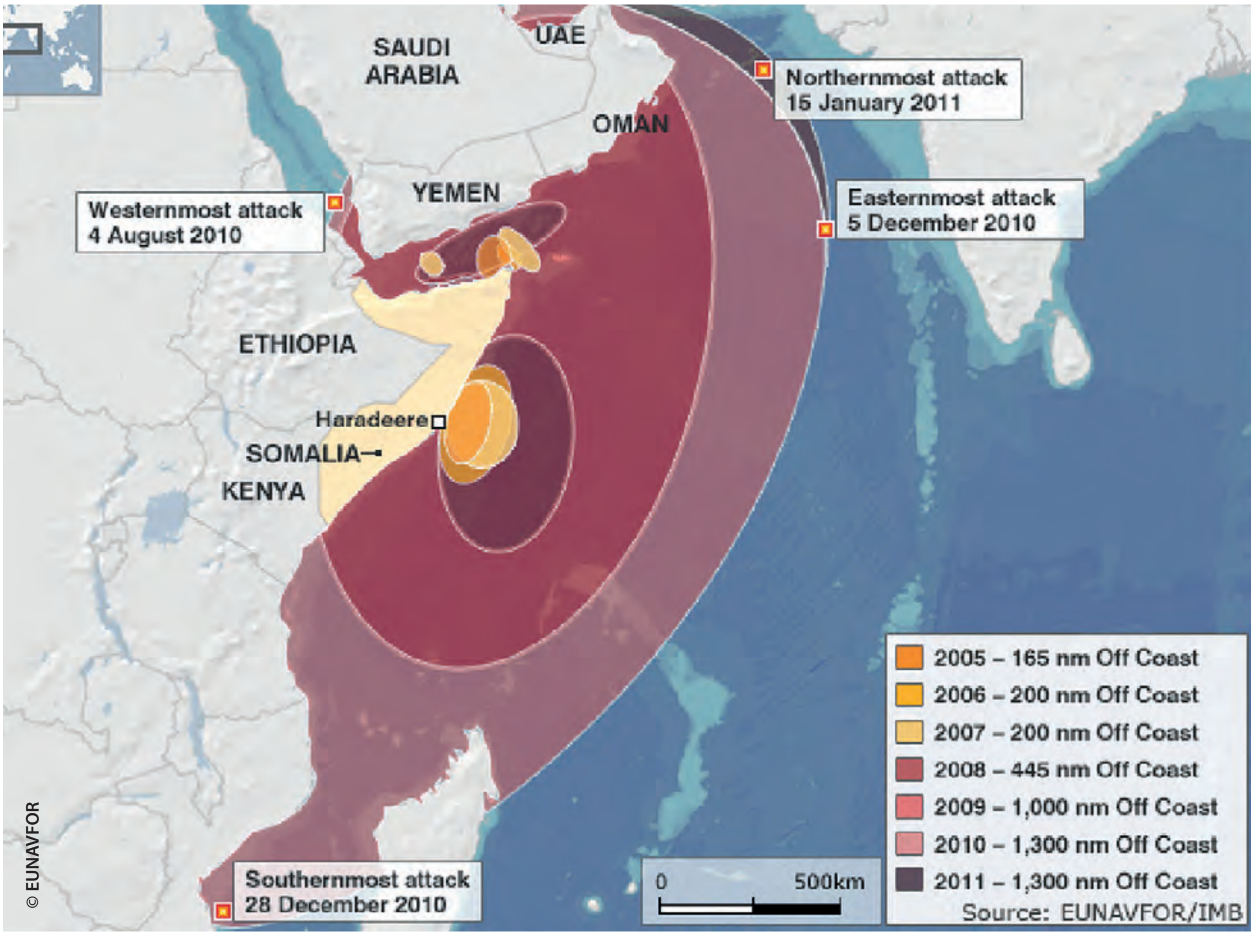


Figure 1-1: Expansion of pirate operations.

1.3.4 Somali pirates have now gained sophisticated operational capabilities which seem to be equal or better than local government forces capabilities.

Pirates are usually equipped with small weapons such as the AK-47 and Rocket Propelled Grenade (RPG) launchers.

In recent years, they have developed technological expertise in the employment of satellite-based navigation and communication systems.

1.4 Pirates' Area of Operations

1.4.1 Somali pirates operate from bases located along the eastern coast of Somalia in the Indian Ocean and the northern coast in the Gulf of Aden (GoA).

1.4.2 Initially, they launched attacks on vessels sailing in the GoA and the waters immediately off the east coast of Somalia, employing small skiffs previously used by fishermen. At that time, their operational reach would not exceed 200 Nautical Miles (NM) off the Somalia shoreline.

1.4.3 In response to international naval efforts to counter acts of piracy and to the increased preparedness of merchant vessels, pirates have shifted their tactics with the intent of finding unprepared shipping.

Pirates started employing so called 'mother ships' which serve as naval support bases for extended operations at sea. These floating stations are larger vessels, provided by fishermen who are forced to support the pirates or, which have been seized ashore or at sea. Mother ships are used as platforms from which smaller and faster boats can perform piracy actions.

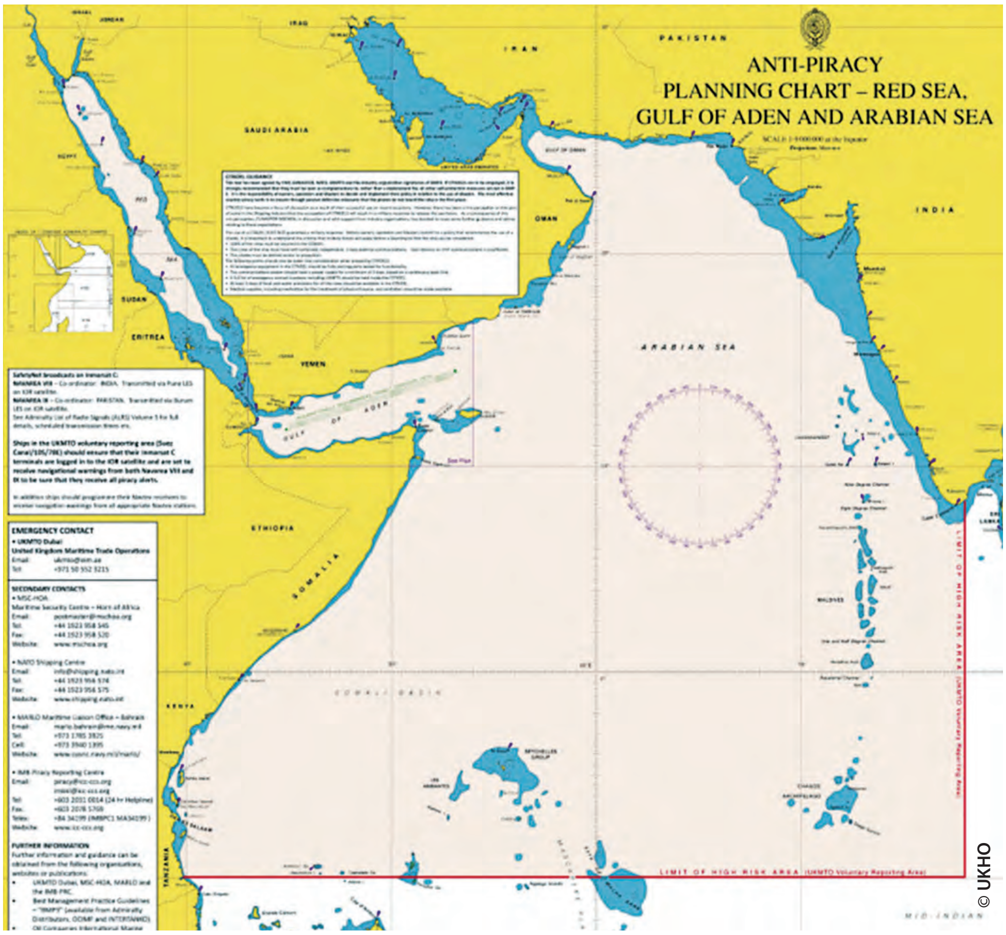


Figure 1-2: Piracy High Risk Area.

The combination of a mother ship and two or more skiffs are identified as a Pirate Action Group (PAG).

1.4.4 As a result of these new tactics, the pirates' operational capability now extends as far as 1,300 NM off the coast of Somalia (see Figure 1-1). The geographic region of piracy now includes the southern Red Sea, the Arabian Sea, the waters off the coasts of Kenya and Tanzania, and the Western Indian Ocean. The Piracy High Risk Area (HRA) now stretches to approximately 2,600,000 Sq/NM (see Figure 1-2).

1.5 Pirates' Tactical Procedures

1.5.1 Pirate attacks can be expected at any time but occur mostly in the early morning hours or during day light. During these attacks, usually two or more fast skiffs which can reach speeds up to 25 knots and have a crew of 10, are launched from the 'mother ship'. When approaching the targeted vessels, they open fire at the bridge causing fear, disorientation and possible injuries to the crew. At the same time, they launch grappling hooks and aluminium or rope ladders to board the ship and overwhelm the crew.

1.5.2 The time frame between the first sighting of attacking pirates and the capture of a ship is usually between 15 to 30 minutes. It is nearly impossible to prevent a capture of the attacked ship because the closest naval ship is often too distant to arrive within that time frame.

1.5.3 As there are indications and examples that pirates target specific vessels, it is very likely some kind of intelligence networking exists. This network is connected to harbour observations and the patrolling of areas with basic visual means. Information flow via mobile phones provides quick coordination of activities and a type of C2 network.

1.5.4 Once a vessel has been hijacked, it is generally moved to a pirate-friendly anchorage. Very often hostages are directly transferred to collection points on larger vessels or to pirate bases on land in order to discourage rescue attempts. Using satellite telephone communication for ransom negotiation, they also use intermediaries and the media to encourage ransom payments. Recent hijackings and subsequent negotiations show that, on average, hostages are in the hands of the pirates for 3 months before being released.

1.6 Pirates' Combat Indicators

1.6.1 Unfortunately, pirate craft offer little in the way of combat indicators to distinguish themselves from legitimate maritime traffic. A medium size vessel (generally a fishing boat or dhow) towing two or three skiffs do not provide certainty of involvement in pirate activity but it can provide a certain level of concern. To increase this level, a closer shadowing of this type of contact could show abnormal behaviour and lead to more precise assessments.

1.6.2 An almost certain means of identifying suspect pirates is by spotting a large number of fuel barrels or specific tools (ladders, grappling hooks, large amount of ropes). While the first are used for extended operations at sea (also applying to fishing vessels), the latter is less common for legitimate activities.

1.6.3 The most direct indication that a crew is involved in pirate activity is the presence of a large number of weapons on board, mostly AK-47 (also carried in limited quantity by legitimate fishermen for self-protection). However, these weapons are generally discovered only after a pirate vessel has been boarded and inspected.

A Spanish Airforce P-3 patrolling the waters off the Horn of Africa.

CHAPTER 11

Bringing Air & Space Power to the Fight Against Piracy

2.1 Introduction

2.1.1 It is without a doubt that the seeds of piracy start ashore; hence the final solution to this criminal activity needs to be found on land. Focusing on a real and decisive answer to defeat piracy, it is commonly recognised that a comprehensive approach is required. This multidimensional method is intended to bring together coherently and effectively the military, diplomacy, humanitarian aid and economic development policy strands.

Unfortunately this process does not provide immediate results; rather it takes years to provide success.

2.1.2 While initiatives by international organisations for increased governance and capacity building continue ashore, simultaneous and correlated military action is also needed. Such action alone cannot provide a final solution to the problem, but it is essential to contain piracy and guarantee the rule of law at sea.

2.1.3 Military intervention with 'boots on the ground' in Somalia is currently unfeasible. The lack of territorial control by the Somali Federal Transitional Government and the unwillingness of the international community to start another war in Somalia (knowing what happened in the past) supports the assumption that any military intervention will be limited to the sea or air.

2.1.4 Multinational naval forces' operations are intended to protect Vessels of High Interest (e.g. World Food Programme) or counter piracy to guarantee freedom of navigation. Increased patrols and proactive efforts by warships, together with improved self-protection measures by mariners, have reduced the number of attempted and successful attacks, but this has not stopped piracy.

2.1.5 Many think Allied naval military forces should take more aggressive measures at sea. However, the use of force against suspected pirate vessels or facilities could simply generate an escalation in violence, prompting the pirate gangs to be correspondingly more aggressive, thereby jeopardising the safety of seafarers and hostages.

2.1.6 Warships offer much to the CP effort. Their inherent flexibility, endurance and reach are key components of a true end-to-end CP capability. Their effect, however, is highly influenced by different factors, mainly the area of operations and the intrinsic characteristics of the 'enemy'.

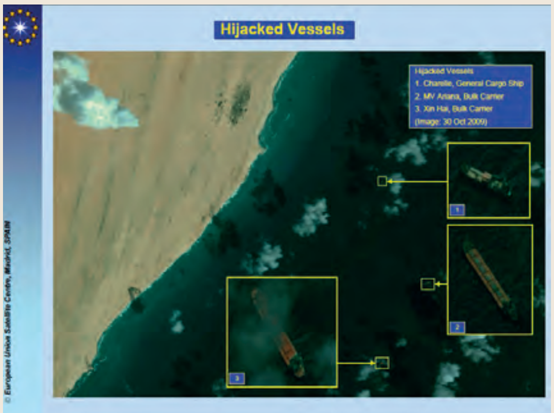
2.1.7 It is quite clear that the area in which pirates operate is simply too vast to be controlled. In 2010, Admiral Mark Fitzgerald, Commander of U.S. Naval Forces Europe and Africa, stated "We could put a World War Two fleet of ships out there and we still wouldn't be able to cover the whole ocean". In 2011, Major General Buster Howes, Operational Commander of EUNAVFOR, stated: "If you wanted to have a one-hour response time in that huge stretch of ocean, you would need 83 helicopter-equipped destroyers or frigates". Due to the costs and the current state of the world economy, it is very unlikely that such a force would be generated to fight piracy off the HoA effectively within assumed budget constraints.

2.1.8 In this situation, *continuous or semi-continuous wide-area surveillance* could detect potential pirate locations, since early detection of impending attacks increases the likelihood that avoidance, suppression or pre-emptive measures will succeed.

Position, Navigation & Timing (PNT)
- Navigation for all forces
- Support to search and rescue, UAV, AIS
- Network timing source (Link16)

ISR
- Imagery
- Radar
- SIGINT
- Monitoring enemy forces
- Mission Planning

Satellite Communications
- C2
- UAV operations
- BLOS communication
- Phone, email, internet, fax
- AIS-S



Environmental Monitoring
- Mission Planning
- Weather forecasting
- Sea State

Figure 2–1: Space applications available to NATO.

2.1.9 A wide-area surveillance system would require specific tools for detection, identification and tracking. Pirate skiffs are not easy to detect in open sea and at long ranges. They are typically small wooden craft with a low radar signature, an especially challenging target for surface sensors. Pirate mother ships and skiffs are sailing vessels like many in the CP area and due to lack of clear combat indicators, it is not immediately possible to distinguish them from vessels with legitimate purposes (fishing, transport, etc.).

Finally, pirate crafts remain at sea in remote regions for long periods; hence tracking of a suspect pirate vessel requires sensor coverage of the track for extended periods.

2.1.10 The air environment is contiguous and covers the land and maritime environments, and air, land and sea all are overlayed by space. A&S Power is therefore uniquely pervasive and offers the prospect of unfettered access to any point on or above the Earth. This affords the opportunity to observe and decisively influence operations in the other environments. In the CP scenario, the military use of air and space would provide a perspective over the whole CP region, ensuring the necessary wide area surveillance capability. Persistent and penetrating A&S assets would also greatly enhance the capability to detect, identify and track suspect pirates, even if operating in remote areas and outside the range of surface (shore-based or sea-based) sensors. Moreover, the ubiquity of air platforms could generate deterrence and discourage acts of piracy.

2.1.11 Despite the support for the CP mission, allied forces were able to achieve only some of the desired effects. Disappointingly, A&S based ISR platforms have not been available in sufficient quantities to match the requirements dictated by this unique operational environment. As a result, the scale of the CP task remains daunting.

2.1.12 Only A&S based ISR has the capability to discriminate 'abnormal behaviours' at sea. The synergistic use of A&S assets could substantially contribute to building a Common Operating Picture (COP), which would increase Maritime Domain Awareness (MDA), providing alerts for mariners and timely and tactically valuable information to commanders at sea. This would increase the speed of response of merchant vessels (i.e. alter course and change speed, initiate protective/defensive measures, request assistance, etc.) and improve the employment of scarce warships (i.e. escort of vulnerable vessels, shadowing pirate crafts, interceptions of PAGs, disruption of attacks, etc.).

2.1.13 Given the stated analysis, two main questions arise:

- What can A&S Power bring to the fight against piracy?
- What is the best way to employ A&S assets in support of CP operations?

The next paragraphs of this chapter will answer these questions with particular attention to non-traditional ISR assets in the Maritime Domain (Space, AWACS, and UAS).

2.2 Space

2.2.1 Figure 2-1, page 10, shows space applications available to NATO. The blocks in brown are part of the daily CP order of battle. They are typically integrated into organisations at the strategic, operational and tactical levels. In fact, many of these capabilities were created to enhance MDA in areas where it was lacking.

2.2.2 A developing area in A&S capability is the *Automatic Identification System (AIS)*. Originally, AIS was designed to communicate with terrestrial base stations and other ships. However, line of sight limitations over broad ocean areas led to the development of satellite AIS applications.

The benefits for maritime situational awareness, and by extension CP, are clear. These satellites detect and communicate transponder locations from large shipping vessels beyond the range of terrestrial tracking stations which are currently limited to roughly 74 Km (approx. 40 NM).

Artist sketch of GeoEye's next-generation, high-resolution Earth-imaging satellite (GeoEye-2) orbiting above the earth. GeoEye selected Lockheed Martin Space Systems Company to build GeoEye-2, which is expected to be operational in 2013. Once launched, the satellite will provide the world's highest resolution and most accurate color imagery to government and commercial customers.

Satellite AIS exists today via several companies and is emerging as a mature and robust technology. However, the low frequency and power of the AIS signal complicates satellite reception. While a small geosynchronous satellite constellation orbiting about the equator would likely provide the capacity and persistence for near global coverage, satellites in higher orbits cannot detect these signals. This limits today's satellite AIS receivers to Low Earth Orbit. Because a single low earth orbiting satellite cannot maintain persistent coverage over a given area, a larger constellation of satellites is required for full-time coverage.

Because of this capability shortfall, Orbcomm is expected to fill that gap. This U.S. company plans to launch a constellation of 18 satellites that will include AIS receivers and could provide near-24 hours global AIS coverage. The constellation should be completed in 2013.

2.2.3 *Imaging satellites* operate typically in Low Earth orbits and only provide access over a given area for a short period (normally single digit minutes). Using the constraints of detecting an object of 1 meter square or larger on the ground, in daylight, and at satellite angles greater than 45 degrees to the target, the German Space Situational Awareness Centre (GSSAC) determined that on average a planner can expect 7 optical commercial satellite imagery passes per day over the coast of Somalia. However, the actual number of available daily passes is likely to be less than 7. This is due to factors such as weather, the capabilities of the ground-station to receive satellite imagery, the ability of the satellite to detect objects that are 45 degrees off of nadir, and cost (see Figure 2-1).

A satellite provider, Worldview, advertises a maximum contiguous area collected in a single pass of 12432 Sq/Km (approx. 3620 Sq/NM). The area of concern for CP off the HoA is estimated at 3,490,000 Sq/Km (approx. 1,000,000 Sq/NM). Under the best circumstances, it would take the Worldview 1 satellite 478 days to image the entire area of concern. For counter-piracy operations, this means optical satellites are best employed against known locations and not used to monitor large

Figure 2–2: AWACS Coverage Area.

swaths of open water. Satellite imagery and exploitation can be used to find new objectives, but the area in which to look should be as bounded as possible. Moreover, using these assets on consistent locations and on a consistent basis allows for the identification of patterns. Once these patterns are understood, deviations from the pattern can be identified and exploited. In this way, space based imagery enables a better understanding of pirate operating characteristics and therefore offers an opportunity to adopt more effective CP techniques.

It is also important to note that imaging satellites may do more than take pictures in the visible portion of the spectrum. They can also detect, if so designed, objects in other portions of the electromagnetic spectrum. This permits detection of objects the human eye is unable to distinguish. Planners must understand that imagery satellites have modes that allow them to see large areas or focus in on key details. For example, it is possible to use different satellites, with various capabilities, as a coherent package to cover weaknesses of individual system. Trading wide area coverage for detailed coverage must be a conscious decision based on mission requirements.

2.2.4 *Radar satellites* are another important ISR platform. Synthetic Aperture Radar (SAR) satellites actively transmit energy to earth and read the returns. Unlike traditional imaging systems, radar satellites can image through clouds. Since they actively transmit energy, they are useful in all weather, day or night. They can also detect returns from equipment that may be camouflaged in the visible electromagnetic spectrum. The resulting image may not resemble the physical object on the ground; however trained analysts can interpret them effectively.

Like imaging satellites, radar satellites often have modes that allow them to view wide areas (with less resolution) or narrow areas (with greater resolution). For example, the Canadian RADARSAT-2 can observe an area up to 250, 000 Sq/Km (approx. 72800 Sq/NM) on a pass but at a resolution that is unusable for ship identification.

© European Naval Force Atalanta

The NATO E-3 AWACS operates a long-range maritime surveillance radar which can effectively complement MPA in CP operations.

RADARSAT-2 can also provide resolution of 14 m with a collection area of 2,500 Sq/Km (approx. 728 Sq/NM). The German TERRASAR-X satellite can view 15,000 Sq/Km (approx. 4368 Sq/NM) with a resolution of 18 m or 1,500 Sq/Km (approx. 437 Sq/NM) with a resolution of 3 m. The GSSAC determined that on average nine commercially available radar passes will occur on a daily basis over the coast of Somalia. However (as in the case with optical satellites), the availability of a pass is not a guarantee of an imaging opportunity.

Nevertheless, satellite radar applications are the first candidate for the surveillance of extensive areas. Man-made objects tend to return radar imagery differently than the natural environment. Furthermore, the differences in materials and shape between ocean going vessels and vessels designed for activities closer to the shore provide additional clues in determining vessel type.

Radar satellites are very technical in their application and analysis. Ms. Stine Skrune, in her Master's Thesis entitled 'Marine Target Characteristics in Satellite SAR Imagery', identified several findings regarding satellite radar detection of vessels at sea. These include:

- Satellite radar imagery can detect vessels but classifying them by type is difficult and actually identifying them is currently unachievable.

- High winds increase radar clutter caused by the ocean and thus decrease the contrast between the vessel and the surface. Therefore, even though radar satellites can image through clouds, their output may still be affected by terrestrial weather.

- Man-made targets tend to have numerous corners and edges which create a characteristic return known to radar imagery analysts.

- Even though vessels in the visual spectrum may differ in size significantly, they may not appear substantially different in radar imagery due to factors such as orientation of the ship, construction material and radar cross section.

- The selected polarisation of energy emitted from and received at the satellite can improve ship detection or wake detection but the modes that enable better detection of ships are not as good for wake detection and vice versa.

2.3 Airborne Warning and Control System (AWACS)

2.3.1 The E-3, with its long-range radar detection and identification system, robust communications, Tactical Data Links (TDL) and Battlespace Management (BM) capabilities make it a unique Command and Control (C2) platform for air assets involved in CP.

Note: The E-2 was not considered in this analysis as it was assumed that it would be tied to an aircraft carrier and a carrier wing would most likely not be available to support CP operations.

2.3.2 The E-3 has a practical unrefuelled endurance of approximately 9 hours, which allows for 60 minutes (400 NM) transit to and from the orbit area and approximately 7 hours on station. Air-to-Air Refuelling (AAR) will extend the endurance significantly and an on-station time of 12–14 hours is feasible. Consequently, its range is approximately 4,000 NM.

2.3.3 Concerning the ISR payload, the E-3 operates a long-range maritime surveillance radar which can effectively complement MPA in CP operations. Pulse radar gives a surface plot capability out to a typical radar horizon of approximately 220 NM. Wide-area coverage range is approximately 140,000 Sq/NM Figure 2-2 (page 13) depicts a typical wide area surveillance profile of the AWACS in the CP region.

2.3.4 AIS signals are now internationally required for many ships, so the E-3 has added new receivers to identify and correlate these additional AIS tracks and potentially include them in its maritime Recognised Surface Picture (RSP). Any identified radar surface track that is not transmitting an AIS signal can be investigated as a potential threat. Other unusual behaviour, such as a ship closing fast on a recognised track, could be reported immediately. The RSP is transmitted simultaneously to NATO and other international forces by Link-16 or Link-11. This real-time ability to transmit data links to maritime ships gives the E-3 a high degree of interoperability with air and surface assets involved in CP operations. An even higher degree of interoperability was recently demonstrated when a Royal Australian Air Force (RAAF) Wedgetail 737 Airborne Early Warning and Control aircraft demonstrated simultaneous C2 of three ScanEagle surveillance UAS. Using special software and NATO-standard sensor and air-vehicle commands, the airborne operators were able to conduct search, reconnaissance, point surveillance and targeting. Real-time video imagery of ground targets was also transmitted. Systems such as the ScanEagle could provide a persistent, cost-effective, ISR capability for use with the E-3 in future CP operations. Learning from the RAAF, NATO similarly tested this concept in exercise EMPIRE CHALLENGE 2010, a United States Joint Force Command (USJFCOM) sponsored live-fly interoperability demonstration. The AWACS received, exploited and transmitted AIS data over a CHAT network and successfully controlled a ScanEagle UAV and its sensors. They used IP-based collaboration with other C2 nodes to compress the kill chain. Five additional operator consoles were recently added to the E-3 fleet allowing additional crew members to fly, augment, and perform new missions and tasks such as ScanEagle control for CP missions. The NAEW&C (NATO Airborne Early Warning & Control) Force has established a Future Capabilities Working Group to pursue these and other promising innovative options in the near-term.

2.4 Unmanned Aircraft System (UAS)

2.4.1 In general, Unmanned Aircraft Systems (UAS) have advantages for applications that are too 'dull, dirty, dangerous' and/or expensive for manned aircraft. In the context of CP operations the current threat level for manned aircraft can be considered low. However, intelligence indicates that pirates use ransom earnings to improve their weapon stocks and the level of violence during their attacks has increased as a response to international naval efforts.

2.4.2 Additionally, UAS have advantages conducting dull and repetitive tasks where long endurance capacities are needed. Compared with manned aircraft, aircrew fatigue can be avoided because the crew may be rotated without landing the aircraft; especially during long endurance applications (e.g. continuous surveillance of large areas).

2.4.3 Furthermore, UAS are able to provide a quick input to organic intelligence, surveillance and reconnaissance, rapidly improving situational awareness (e.g. providing imagery of pirates' bases and ports or visual information on pirate vessels or hijacked ships to commanders or boarding teams).

2.4.4 From a wide area surveillance perspective, the real game changer in CP operations could be the employment of a High Altitude Long Endurance (HALE) UAS. The MQ-4C or Broad Area Maritime Surveillance (BAMS) UAS, is a US Navy-specific development of the Global Hawk equipped with a navy-specific Tactical Control System (TCS). The main differences from the U.S. Air Force Global Hawk are the full 360-degree field of regard for the radar system and the capability to collect Full Motion Video (FMV). Due to its size, BAMS UAS requires a runway for take-off and landing and is not carrier-capable. The BAMS UAS is part of a broader US-Navy program that includes a manned P-8 Multimission Aircraft (MMA), and the MQ-8 Fire Scout VTUAV (Vertical take-off and landing Tactical Unmanned Aerial Vehicle), to recapitalise the capability of the aging fleet of P-3 Orion aircraft. The BAMS TCS will be collocated with the base for the BAMS UAS and the P-8 MMA, which will be able to receive data directly from the UAS.

Its general task is to provide the US-Navy with persistent maritime surveillance and reconnaissance coverage of wide oceanographic and littoral areas. The BAMS UAS is a multi-mission system to support strike, provide signals intelligence and communications relay. Therefore its missions include, but are not limited to,

The Northrop Grumman MQ-4C Broad Area Maritime Surveillance (BAMS) UAS, is a US Navy-specific development of the Global Hawk equipped with a navy-specific Tactical Control System (TCS).

The Boeing ScanEagle Tactical UAV can be launched and recovered from warships, providing the commanders at sea with 'extended eyes' on the tactical picture.

maritime surveillance, collection of enemy order of battle information, battle damage assessment, port surveillance, communication relay, and support of the following missions: maritime interdiction, surface warfare, BM, and targeting for maritime and littoral strike missions.

MQ-4C BAMS UAS provides persistent maritime ISR at a mission radius of 2000 NM, 24 hours/7 days per week with 80% Effective Time On Station (ETOS). These specifications and the sensors package (Multi-Function Active Sensor Active Electronically Steered Array radar, Electro-optical/infrared, FMV, AIS) make the BAMS a highly capable asset to substantially support surface forces with detection, identification and tracking capabilities.

2.4.5 Tactical Unmanned Aerial Vehicle (TUAV) is also an essential asset in the UAS market. Their limited size and high flexibility allow them to be operated from warships, avoiding long transit time from shore bases and providing the commanders at sea with 'extended eyes' on the tactical picture. As an example, the US ScanEagle UAS has proved quite effective in current CP operations. It includes a small TUAV, optimised for endurance (24 hours) rather than payload. Its primary maritime task is to provide persistent ISR in support of Maritime Interdiction Operations (MIO) (e.g. information about number and disposition of personnel aboard a vessel). The ScanEagle UAS can be launched and recovered from a wide spectrum of ships, including those that do not have any type of flight deck. The ScanEagle platform has a payload capacity of around 13 lbs, and a loiter speed of 49 knots. It is launched via a pneumatic catapult and recovered using a Skyhook. The ScanEagle usually operates via line of site (LOS) data links and employs high resolution day/night electro-optical/infra-red sensors. However, other sensing capabilities (such as SAR and chemical/biological) are under development as well as a satellite Iridium data link for Beyond Line Of Sight (BLOS) communications.

2.5 Maritime Patrol Aircraft (MPA)

2.5.1 The biggest advantage of the MPA is the excellent mix of long endurance, high speed, on-board sensors and specially trained aircrews.

2.5.2 With an endurance of 10 to 13 hours, the MPA can patrol large areas with the flexibility to revisit points of interest repeatedly. Due to the robust design

Maritime Patrol Aircraft, such as this P-3C Orion, fill a key role in Counter-Piracy operations.

and foul weather equipment, the MPA is an almost all weather capable asset which is effective in challenging environmental situations.

2.5.3 Modern MPA incorporate a wide variety of sensors, such as visual, radar, electro-optical, AIS, Electronic Support Measures (ESM), communication relay capabilities and video relay capabilities.

2.5.4 In combination with this diversity of sensors, the MPA is operated by specially trained aircrew optimised for naval operations. This leads to the optimal use of available sensors depending on the tactical situation, the mission task, the environmental influences and the target behaviour. Another great advantage is the fact that aircrew can easily change tactics, focus areas or even the whole mission if the requirements dictate. In addition, MPA can be used as a sensor platform or as a command cell, commanding a surface operation from the air.

2.6 Rotary Wing (RW)

2.6.1 Rotary wing assets are an integrated component of Naval Warfare for the projection of Maritime Power. The sensors and weapons of warships rely on, and are enhanced by, the natural characteristics of speed, range and flexibility (relative to surface ships) of sea-based helicopters.

2.6.2 When used in the CP mission, a helicopter is a mobile, elevated platform for observing, identifying, and localising PAGs beyond the parent ship's radar. When a suspected threat is detected, data is provided to the parent ship via voice or data link for maritime picture update. The effective surveillance, detection, classification, and targeting ranges of the ship are greatly extended. Sea-based helicopters are designed to operate from ships mainly in support of Surface Surveillance and Control, Subsurface Surveillance and Control, and utility operations. Hence their limited endurance and sensor range are not suitable for a continuous wide surveillance system needed to build a COP in CP operations off the HoA. Nevertheless, helicopter EO/IR systems can assist by providing high quality surveillance products, identification of pirates vessels detected by other means (aircraft or ship) and intelligence collection on pirates' bases and ports. They also provide a crucial link in the chain, from intelligence cueing (AWACS/HALE/MPA), target identification and shadowing (MPA/TUAV), to end-game activities.

HMS Somerset's Merlin helicopter firing its machine gun across the bow of a dhow, belived to be the mothership of the pirate group that failed to take the MV Montecristo (October, 2011).

2.6.3 Helicopters provide their most valuable contribution in MIO. It is reported that several attacks were thwarted by naval helicopters from ships operating either as part of international naval task forces or on independent anti-piracy missions. As a matter of fact, the helicopter's speed advantage over surface ships allows it to respond rapidly to distress calls despite extended distances.

2.6.4 Moreover, helicopter hover capabilities allow them to conduct at-sea retrieval or ship boarding operations even where no suitable landing area exists, as on most merchant vessels.

2.6.5 Helicopters also provide fire support during insertion of troops from the sea or conduct Medical Evacuations (MEDEVAC), of injured boarding team members or crews of attacked vessels.

2.6.6 Helicopters are also routinely tasked to perform a wide range of utility missions, including search and rescue, cargo and personnel transfer, which could be extremely useful in the CP scenario.

2.6.7 In summary, a sea-based helicopter is not the perfect tool for persistent surveillance but is one of the key components for the end-game action in countering piracy.

2.7 A&S ISR Concept of Operations in CP

2.7.1 In CP, given the vastness of the Area of Operations (AO), a multi-layered ISR Concept of Operations (CONOPS) to deliver actionable intelligence to ships at sea should be adopted (see Figure 2-3). This CONOPS requires a 'sensor oriented approach', given the assumption that combining sensors reveals a more complete picture. It also implies the synergistic and orchestrated employment of a composite 'system of systems', in which all components provide different or complimentary capabilities for the accomplishment of the CP mission.

2.7.2 This concept places Space assets, HALE and AWACS/MPAs in a high orbit, MPAs and TUAVs in a medium-to-low orbit, while warships are in the area with their organic helicopters in flight or on alert. Assets feed off one another in a series of cross-cuing, typically from high to low.

2.7.3 Space-based and air-based AIS can provide the basis of a real time, high resolution picture of co-operating maritime shipping. This basic picture can be further enhanced for military use by the employment of sensors embarked on both manned and unmanned assets, providing raw contact data of non-cooperating vessels to command nodes, both ashore and at sea.

2.7.4 Comparing AIS information with data from other sensors (SAR, maritime radar, optical, infrared, etc.) allows the detection of potential irregularities and discrimination of 'abnormal behaviours'.

2.7.5 NATO AWACS and modern MPAs are key enablers in this role and can merge commercial AIS data with their own organic picture on board to give a complete contact plot of all vessels at sea in specifically designated regions. Digital LINK networks can disseminate the picture, providing a common operating picture to CP units. HALE UAS will offer a similar capability plus the advantages of a much extended endurance and high resolution imagery capability.

2.7.6 At this stage, an additional layer is required to provide target identification and track correlation. The deployment of MPAs or TUAVs (eventually equipped with Full Motion Video) ensures the collection of further information with higher spatial and temporal resolution and possibly the identification of a piracy threat. In this way the 'detect-identify-track cycle' is complete; the relevant data is passed up the C2 chain. Commanders can then evaluate the threat and have the option to issue alerts to merchant vessels or initiate shadowing or interdiction with surface assets or organic helicopters.

2.7.7 This CONOPS also provides the advantage of reducing the patrol burden on surface ships, allowing them to pre-position to areas of interest, which enhances deterrence and increases the probability of successful intercept of PAGs.

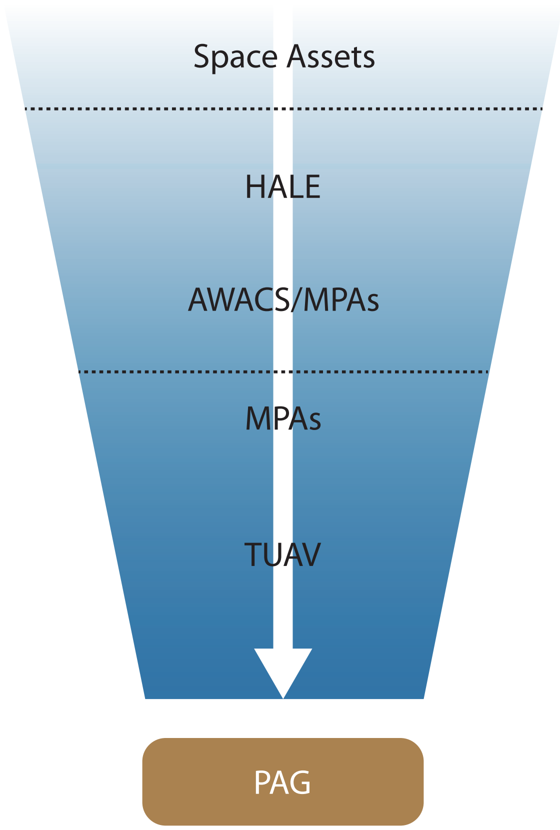


Figure 2–3: Multi–layered ISR CONOPS.

CHAPTER III

Experimental Approach to A&S Power in CP Operations

3.1 Introduction

3.1.1 Chapter II provided an insight on the possible added value of A&S Power in the fight against piracy and the best way to employ A&S assets, specifically ISR, in support of CP operations. The logical subsequent question is, what is the best mix of A&S ISR assets to efficiently support commanders at sea?

3.1.2 Unfortunately, this question cannot be answered by trials and exercises due to the high costs involved and the unavailability of assets which are generally employed in priority missions such as International Security Assistance Force (ISAF). An alternate means of analysis is therefore required. An experimental approach is the most affordable and logical method to meet this objective.

3.1.3 Based on conceptual rationale, an experiment is a controlled investigation to discover information, confirm or disprove a hypothesis or formally validate a concept. Experiments generally reduce uncertainty, identify and solve practical problems that cannot be determined through studies and analysis alone and help to avoid production of systems that appear promising, but that in reality offer little in terms of improved capability.

3.1.4 Defence experiments are uniquely suited to investigate cause-and-effect relationships providing operational analysis and underlying capability developments that will increase effectiveness in operations and enable innovation and transformation.

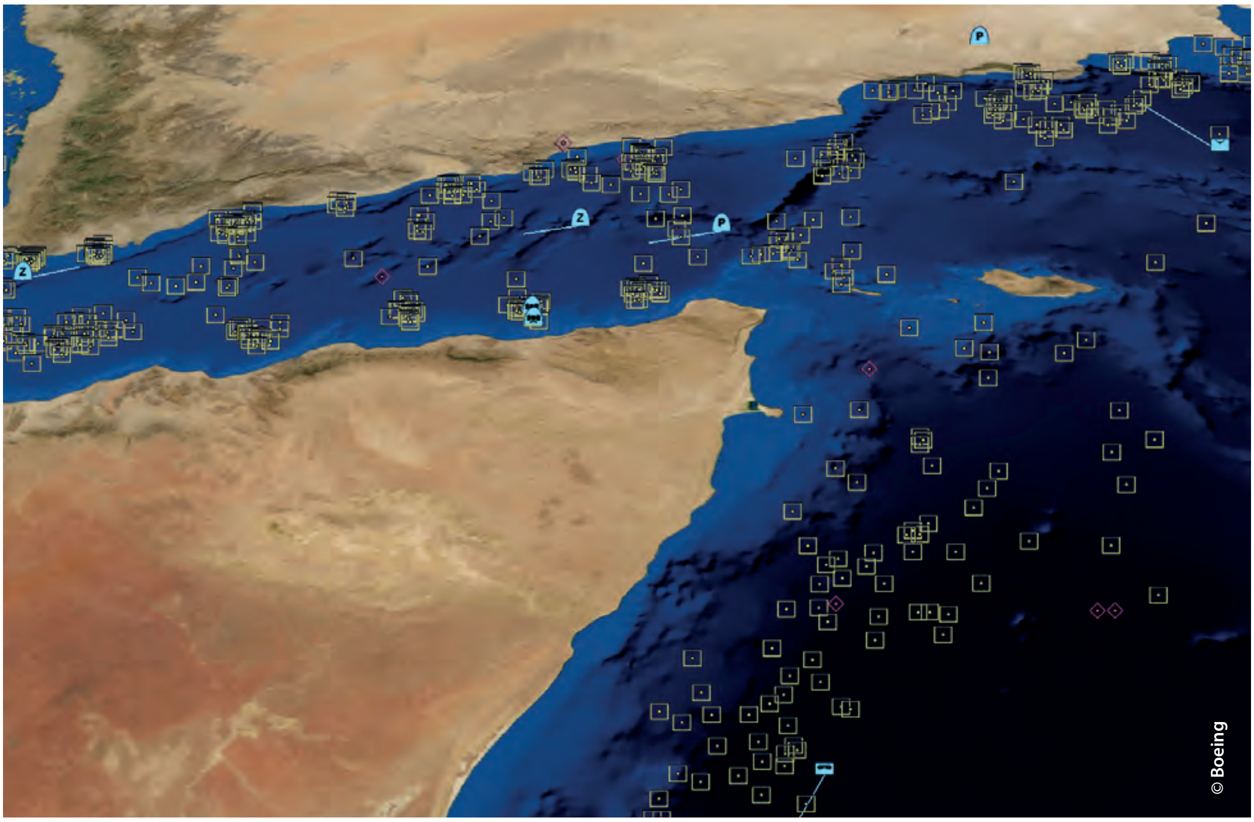


Figure 3-1: Simulation Screenshot (Ground Truth).

3.1.5 'Discovery' experiments are aimed at introducing novel systems, concepts, organisational structures, technologies, or other elements to a setting where their use can be observed and catalogued.

3.1.6 A 'discovery' experiment usually occurs early in the exploration of a capability (often used in the early stage of Concept Development) and is often used to clarify problems discovered in operations, exercises and through lessons learned feedback.

3.1.7 'Discovery' experiments are generally accomplished through Modelling and Simulation, a discipline for developing a level of understanding of the interaction of the parts of a system, and of the system as a whole.

3.1.8 A model is a simplified representation of the actual system intended to promote understanding. Whether a model is a good model or not depends on the extent to which it promotes understanding. Since all models are simplifications of reality there is always a trade-off as to what level of detail is included in the model. If too little detail is included in the model one runs the risk of missing relevant interactions and the resultant model does not promote understanding. If too much detail is included, the model may become overly complicated and actually preclude the development of understanding.

3.1.9 System Simulation is the mimicking of the operation of a real system properly modelled. A simulation generally refers to a computerised version of the model which is run over time to study the implications of the defined interactions.

3.1.10 These concepts were first applied in conducting a theoretical study to determine the number of MPAs needed to maintain different percentages of surveillance in the CP area by using the experimentation capability provided by the Boeing Portal (based in Fleet, UK).

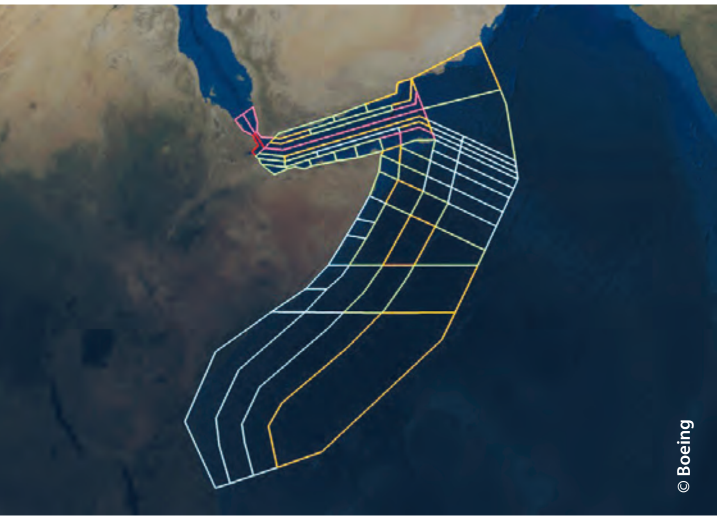


Figure 3-2: Area of Operations and priority zones.

3.1.11 The results of this initial experiment, designated OCEAN SHIELD 1 (OS1), were published in the JAPCC Journal Edition 12 in an article entitled 'Strategy versus Capability: The Non-Contribution of NATO A&S Power to Counter-Piracy'. Although purely hypothetical, the experiment showed the potential offered by the Boeing Portal and paved the way for a broader and more detailed study. The conclusion clearly demonstrated that piling up MPAs to patrol the CP area was not appropriate. This led to a new experiment titled Ocean Shield 2 (OS2) executed under cooperation between JAPCC and the Boeing Portal.

3.1.12 This chapter will describe OS2 in full and report the key insights into the commitment levels of A&S ISR assets required to provide a significant contribution to CP operations off the HoA.

3.1.13 It must be emphasised that as this tasking was conducted and delivered using 'discovery' experimentation, it is not recommended that any key investment decisions be made on the insights derived without first conducting more detailed study.

3.2 Experiment Intent

3.2.1 The primary intent of experiment OS2 was to provide insights into how differing commitment levels of integrated A&S platforms can enhance regional MDA. This information could then be used by all maritime users for the avoidance of PAGs, or to assist military/police action in CP operations.

3.2.2 These insights can inform the wider debate on future NATO commitment levels for countering the piracy problem in all potential regions of responsibility.

3.3 Experiment Aim

The aim of the experiment was "to conduct discovery experimentation to gain insights into potential commitment levels of A&S ISR platforms available to NATO for attainment of MDA in the CP Region off the HoA in the near-term time frame".

3.4 Context

3.4.1 The experiment was conducted using a faster-than-real-time, computer controlled, constructive simulation (see Figure 3-1) model (A 'System of Systems' approach to the development of MDA). The model consisted of a variety of A&S ISR capabilities (available to NATO in the near term future), providing data for a notional integrated COP which was used to efficiently task Detection, Identification and Tracking assets in order of priority. All data used was Not Protectively Marked (NPM)/Unclassified.

3.4.2 It was proposed that Detection, Identification and Tracking of suspect pirates for MDA was key to advising NATO on potential force development and CONOPS for existing and future A&S surveillance assets. This would not include physical interdiction of pirate forces.

3.5 Military Scenario – Surface

3.5.1 The AO is defined broadly by an eastern boundary running parallel 500 nautical miles from the coast of Somalia, and projected south to the border between Tanzania and Mozambique. It includes the entirety of the GoA and a portion of the Red Sea north of the strait of Bab Al Mendeb (BAM). The region contains approximately 1,000,000 Sq/NM of ocean and was divided into zones for asset tasking management (see Figure 3-2).

Figure 3-3: IRTC, pirate bases and friendly forces air bases.

3.5.2 The Internationally Recommended Transit Corridor (IRTC), established in 2009 in order to aid protection of merchant shipping 'Transit Groups' is highlighted in Figure 3-2 and Figure 3-3.

3.5.3 As depicted in Figure 3-3, eight pirate base ports were used (7 in Somalia and 1 in Yemen). These were Mogadishu, Hobyo, Garacad, Eyl, Abo, Calula, Bosaso, Al Mukallah (Yemen).

3.6 Scenario Overview

The scenario was baselined on an approximation of the A&S assets deployed in mid-2011. From this baseline, differing levels of commitment were examined. These commitment levels (defined as 'treatments') were developed and described as LOW, MEDIUM, and HIGH.

The CONOPS of these assets was deliberately simplified to match resource constraints on the conduct of the experiment.

3.7 'Pattern of Life' (PoL)

In order to provide a representative operating environment capable of taxing the system, a composite 'Pattern of Life' (PoL) was created for high seas merchant shipping, local traffic, fishing vessels, and pirate activity. Maritime PoL (MPoL), Pirate PoL (PPoL), and pirate bases were determined from a combination of open source literature review and JAPCC research. The principal source for merchant traffic PoL was an open source snapshot of AIS traffic in the region from March 2010 (seen on the left of Figure 3-4). MPoL was randomly generated with approximately 10% of this traffic allocated as 'Non-AIS' in order to simulate traffic either not required to carry AIS, or having AIS unavailable but still following 'sea lanes'. Local traffic journeyed between local ports within the region often crossing 'sea lanes' and did not carry AIS and fishing vessel fleets were established in littoral areas. PPoL was then added to complete the simulated environment. Unlike MPoL, PPoL was scheduled in order to avoid multi-variant analysis errors.

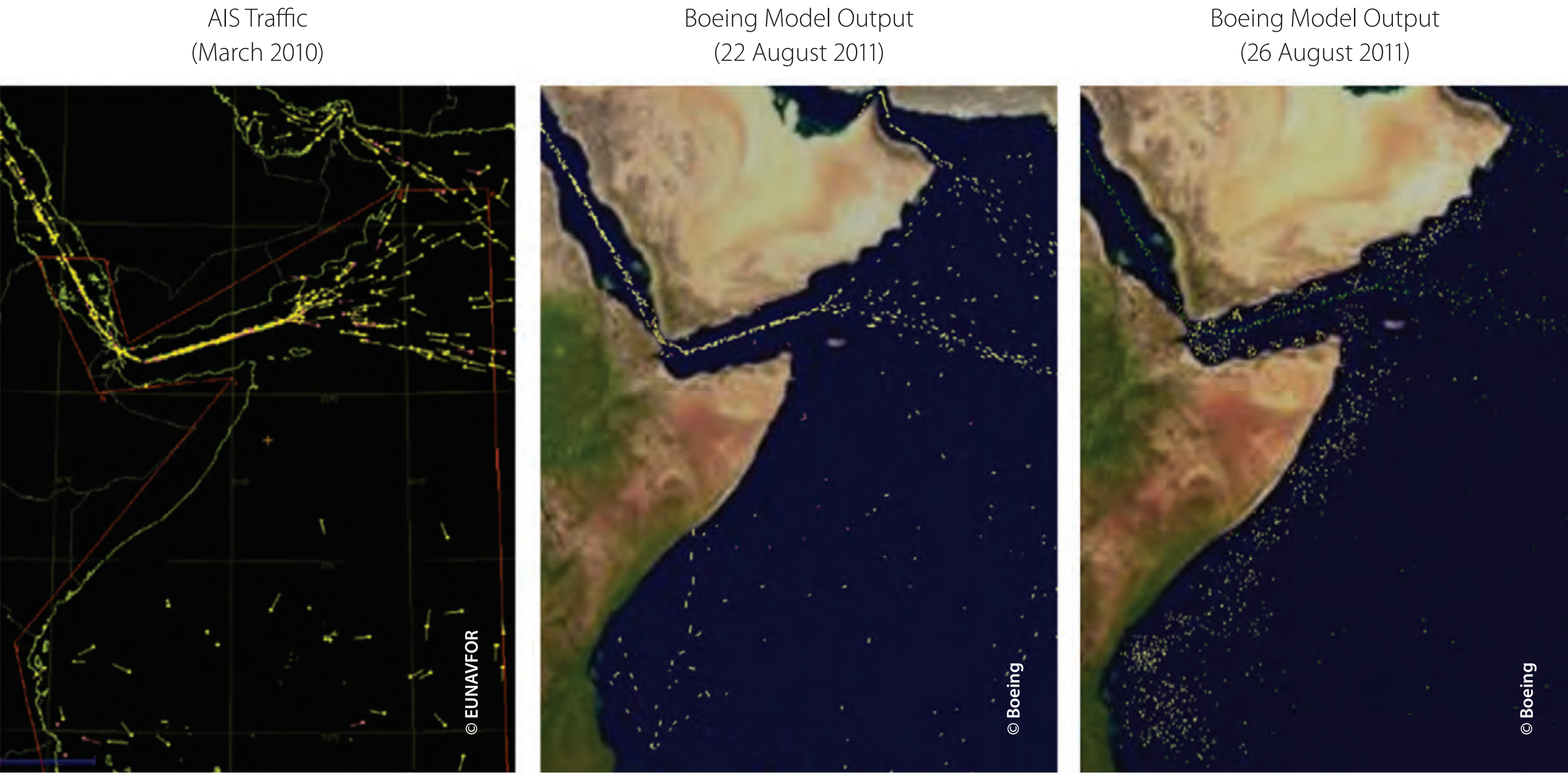


Figure 3-4: Maritime Pattern of Life (MPoL) evolution.

3.8 Scenario Time Line

The experiment was based in the near-term time frame, with equipment and capabilities likely to be available within the next five years. This allowed the employment of significant increases to capability provided by global AIS satellite coverage and the introduction to service of maritime HALE UAS platforms.

3.9 Capability Outlines

3.9.1 Four different treatments (A-D) were considered (Table 3-1, page 26). The key variable between treatments was sortie availability. Therefore pure platform numbers were not considered. To reduce the danger of multi-variant analysis further, all platforms used in the simulation comprised the same capabilities throughout the treatment set, on each run. The increased commitment by treatment is depicted in Figure 3-5 on page 26.

3.9.2 In Case A it should be noted that there were no SAR satellites, HALE or AWACS. The number of optical satellites, MPA, and TUAV were limited to a single sortie per day. In Cases B-D, 24 hour AIS coverage was provided for the entire area and sortie rates approximately doubled as commitment levels increased with treatment.

3.9.3 All platforms operating data was derived from open sources, such as JANES or manufacturer websites. Figure 3-6 (page 27) illustrates how platforms were employed appropriate to their capabilities (i.e. speed, endurance, sensor fit). They were referred to as 'HIGH BOY' or 'LOW BOY'. HIGH BOYS such as HALE UAV, AWACS and MPAs flew scheduled routes and provided overlapping coverage, whilst constantly contributing to the COP. LOW BOYS were reactive and allocated according to priority tasking. MPA flights were divided into two categories, those dedicated as Detection Assets (HIGH BOY) and those dedicated as Identification Assets (LOW BOY) and therefore they were essentially treated as different platforms. LOW

A. Current Platforms
B. NATO Low
C. NATO Medium
D. NATO High

	A	B	C	D
AIS Satellite	24 Hr	24 Hr	24 Hr	24 Hr
SAR Satellite	0	2	4	9
Optical Satellite	1	2	4	7
HALE	0	1	2	4
AWACS	0	1	2	4
MPA	1	4	10	20
T-UAV	1	4	8	16

- Treatment A Current air and space assets (Baseline)
- Treatment B NATO Low commitment
- Treatment C NATO Medium commitment
- Treatment D NATO High commitment

Table 3-1: Summary of number of sorties/passes per day, by platform, across all treatments.

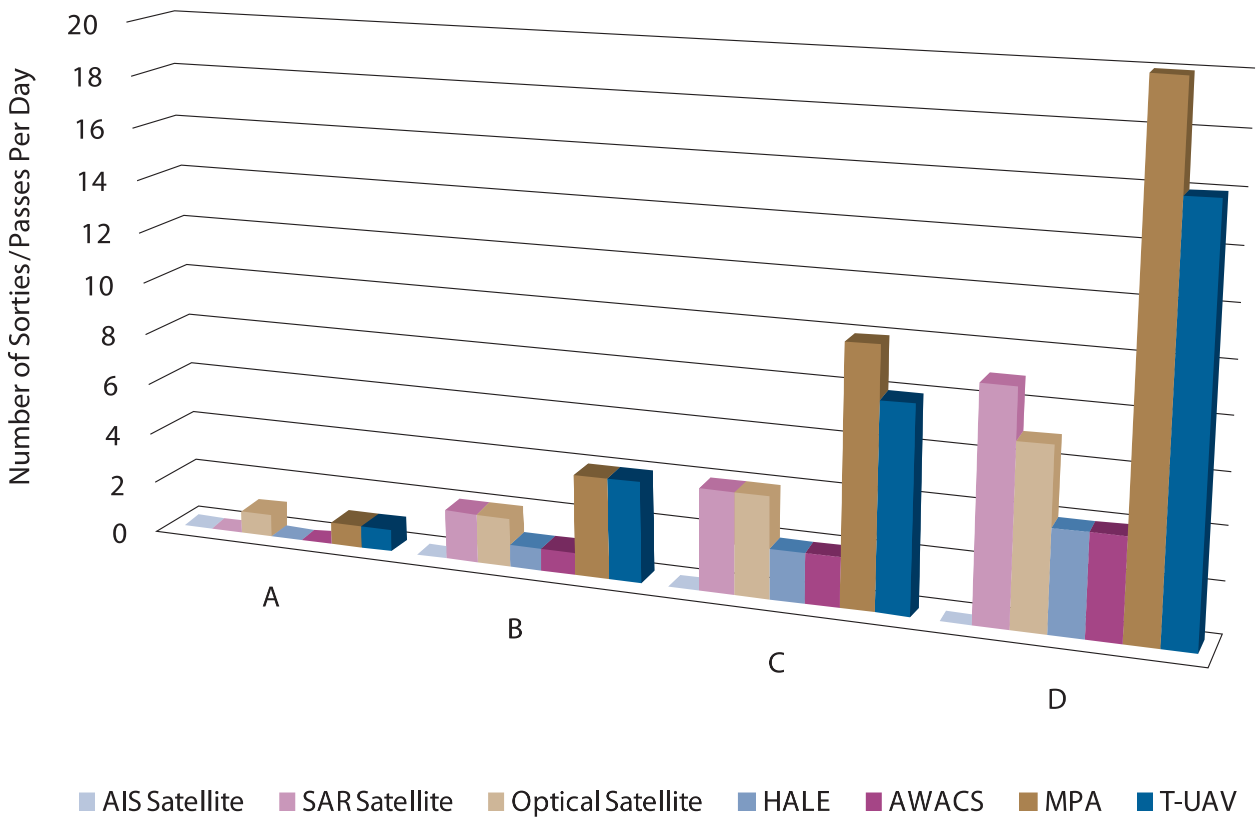


Figure 3-5: Increased commitment by treatment.

Figure 3-6: Platform employment by capability.

BOY MPA basing was ⅓ at Djibouti, and ⅔ at Thumrait (on alert). TUAVs were based at Djibouti and on notional commercially operated marine launch platforms distributed throughout the north of the region on alert.

3.10 Patrol Routes

3.10.1 HALE UAV – All Thumrait based, 24 hour patrol, covers IRTC 'Delta' and Somali Basin (Figures 3-7 and 3-8, page 28).

3.10.2 AWACS – All Thumrait based, 10 hour patrol, covers IRTC 'Delta', GoA and BAM. (Figure 3-9, page 28).

3.10.3 MPA 'HIGH BOY' – Djibouti and Thumrait based, 11 hour patrol, covers GoA and BAM. (Figures 3-10 and 3-11, page 28).

3.10.4 SAR Satellite Product – 1,500 Km x 100 Km (approx. 810 NM x 54 NM), auto-processed Vessel Detection System (VDS) (Figure 3-12, page 28).

3.10.5 EO Satellite Product – Indications & Warnings (I&W) from change detection in pirate bases. (Figure 3-12, page 28).

3.11 Methodology

3.11.1 A constructive simulation engine provided the capability to run the experiment sequence multiple times at faster than real time speeds.

3.11.2 The first stage of the experiment development phase was the establishment of a geo-specific terrain set. This terrain set was then used as the basis for the development of a constructive simulation of the AO. It was deemed critical to the success of the analysis that enough 'traffic' was included to provide a rich enough environment in which to test the varying sensor sortie rates. The initial Synthetic Environment (SE) developed was a 'simplified' network of sea lanes, local traffic, and fishing vessel concentrations and was designed to provide a reasonable approximation of real world MPoL. Civilian traffic MPoL was randomly generated for the duration of the simulation runs.

3.11.3 Four major pirate bases were identified from an open source literature survey (Bosaso, Eyl, Hobyo and Mogadishu), and four minor bases (Al Mukallah in Yemen, Calula, Garacad and Abo). These were laid down in the SE using geospatial data sets in lat/long. Then, a detailed PPoL was constructed and scheduled

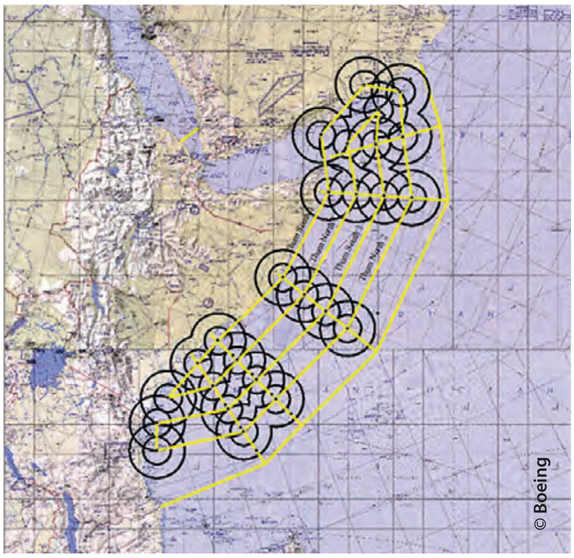


Figure 3-7: HALE 'Close Coast' Route.

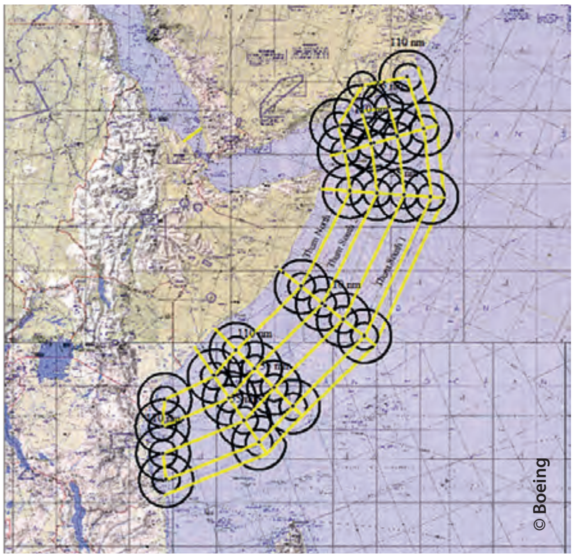


Figure 3-8: HALE 'Outer Edge' Route.

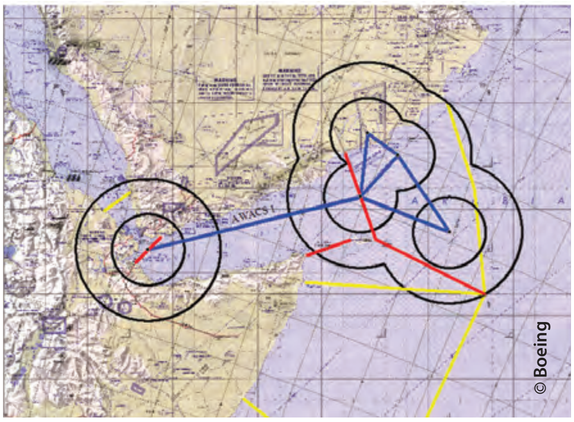


Figure 3-9: AWACS Patrol Route (Repeats once).

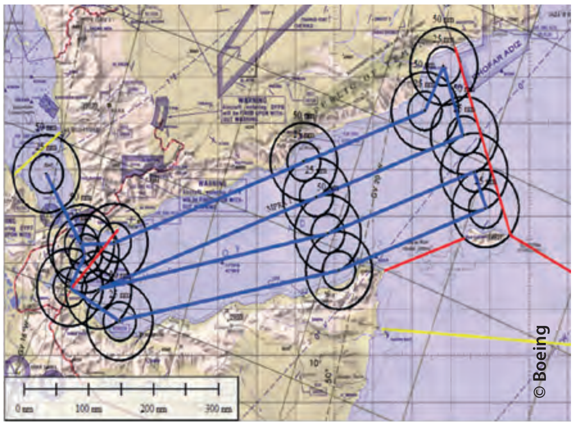


Figure 3-10: MPA Djibouti Based Route.

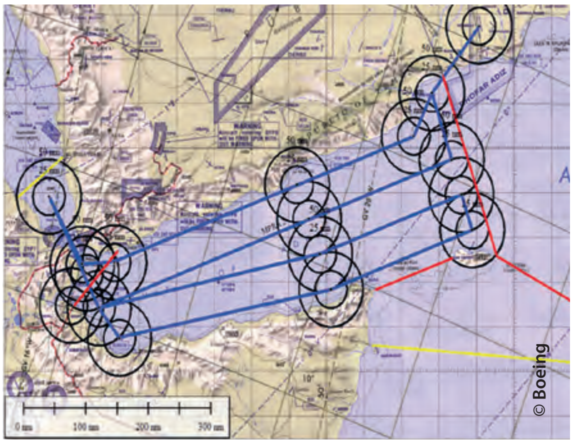


Figure 3-11: MPA Thumrait Based Route.

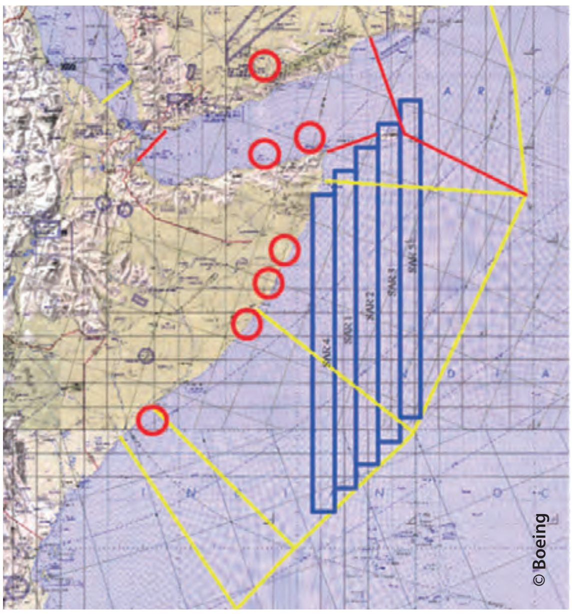


Figure 3-12: SAR Satellite Swaths and EO Satellite Spot Surveillance Areas.

using realistic time/speed/distance calculations and overlaid onto the model. In order to allow cross treatment experimental comparisons, it should be noted that the PPoL ran identically across all treatment runs.

3.11.4 The next stage of the experiment was the development of complex BLUE FORCE Concept of Employment (CONEMP) C2 algorithms to represent operational control logic via scripting in the constructive model. The asset tasking logic was drafted and matured throughout the development process. The AO was divided into 64 zones (see Figure 3-2) all possessing a zonal priority value (values were higher nearer to sea lanes). LOW BOY zonal sanitisation asset tasking was triggered by zonal priority exceeding the zone's threshold value. Zonal priority was a figure based on the number of detections in that zone, multiplied by its zonal constant. In addition, the identification of a suspect pirate by a HIGH BOY asset would trigger the zonal priority level to be increased, by a large amount, called the 'P factor'. The closest LOW BOY MPA was then tasked to sanitise the zone and on identifying a suspect pirate would task the closest available TUAV to track. TUAVs would continue to ripple handover tracking responsibility until either there were no TUAVs available or the suspect pirate returned to port.

3.11.5 NATO air sorties were allocated by representative Air Tasking Orders (ATO). The ATO was part scheduled, part reactive, and responded to the PoL and asset tasking logic as presented on each run.

3.11.6 Platforms were employed appropriate to their capability and were designated either 'HIGH BOY' or 'LOW BOY' in role. They were scheduled or reactively tasked to patrol areas appropriate to their sensor capabilities, speed and endurance. HIGH BOYS were all capable of detection and some capable of identification; they included satellites, HALE UAV, AWACS, and 'HIGH BOY' MPAs. LOW BOYS were more ideally suited to identification and tracking and consisted of TUAVs and 'LOW BOY' MPA. MPAs were divided into dedicated Detection Assets (HIGH BOY) and dedicated Identification Assets (LOW BOY) and treated as different platforms. They were divided roughly 20 % HIGH BOY: 80 % LOW BOY (with a minimum of 2 HIGH BOYS).

3.11.7 The final stage of the experiment development was the testing and integration of all simulation components. The simulation contained over 2,000 entities at any one moment in time and was run constructively ('faster-than-real-time') for a period of 3 weeks (simulation time).

3.11.8 The data captured was transposed into an analysis software tool to enable rapid and agile analysis for the identification of the insights.

3.12 Limitations

3.12.1 It should be noted that this study was conducted under the auspices of a 'discovery' experiment methodology, which is well suited to introducing novel systems, concepts and organisational structures or technologies, and highlighting where more comprehensive investigation should be directed.

3.12.2 As this was a 'discovery' experimentation (hence not to be considered as being fully statistically significant), no investment decisions should be made based directly on the insights derived, unless further experimentation and/or analysis is conducted.

3.13 Constraints

- All information and input data used was open source or NPM/UNCLASSIFIED.
- The Experiment had to be comparable to OS1.
- Only representative (not precise) platform and sensor operating data were used.
- Scenario was set in the near-term time frame with expected NATO capabilities (approximately 2016).
- MPA, AWACS and HALE UAV were based in Thumrait or Dijbouti.
- Dar Es Salaam and Seychelles were made available for refuel if required.
- Optical Satellites only provided imagery during daylight hours.

- SAR Satellites produced one product per pass, due to memory and bandwidth restrictions (i.e. one consecutive 1500 Km x 100 Km (approx. 810 NM x 54 NM) 'ScanSAR' image).

- The CONOPS were deliberately simplified to match resource constraints on the conduct of the experiment.

3.14 Assumptions

- Weather and Sea State (SS) were constant: Ceiling And Visibility OKay (CAVOK)[1], SS3 (Pirates do not operate >SS4).

- Full constellation of AIS Satellites available (24 hr coverage of region; every 15 mins).

- All allied air assets capable of interrogating AIS.

- AIS is not spoofed and all AIS fitted vessels have AIS switched on.

- Six (6) generic platforms to be considered: EO Sat, SAR Sat, HALE (BAMS), AWACS (E-3), MPA (P-3), and TUAV (ScanEagle).

- Sufficient basing available for all air platforms (including ScanEagle surface launch platforms).

- Organic maritime helicopters not considered, as due to their multi-role capabilities cannot be relied upon, and have very limited endurance.

- Commercial contracts are in place for dedicated access to satellites, and commercial/military precoordination and methods of communication are in place for harmonised tasking, retrieval and processing of imagery.

- Optical Satellites are best suited to provision of I&W of pirate activity in the vicinity of pirate home ports.

- SAR satellite imagery is best suited to aiding target reduction and zonal priority in 'blue water' areas.

- Time correlated AIS data can be overlaid on to satellite imagery.

- All platforms are data-link capable, interoperable, and uninterrupted among all assets.

- A COP is maintained at a notional maritime headquarters and distributed via satellite/web/data link without interruption, to all assets.

- Asset Logic Flow applies only to Non-AIS contacts.

- PAG mothership length = 18 m/60 ft, Skiff length = 6 m/20 ft.

3.15 Asset Tasking Logic

As the constructive simulation did not allow real-time human manipulation or decision making it was important that logical 'decisions' could be made by the model with regard to asset tasking. The model did not contain a comprehensive C2 element but a simplified logic was followed. The model Asset Tasking Logic is shown in Figure 3-13.

3.16 Experiment Environment

In order to meet the simulation requirements, experiment OS2 was executed using Boeing-owned software applications, faster than real-time, constructive simulation engine framework. In OS2, simulation software was run stand-alone without user interaction, enabling a simulated experiment period of three weeks to be run in anywhere between 2 and 36 hours, dependent on the treatment set.

3.17 Architecture

3.17.1 During the 21 days run, an average 24 hour period in the software scenario contained over 2,000 entities, operating within 1,000,000 Sq/NM of ocean. Computers generated a series of output files containing source data to drive the analysis process. This included data detailing simulated platforms 'ground truth' locations, sensor usage profiles, detection results, target identifications, tracking metrics and fuel usage and endurance statistics. These data files were then loaded into another tool, which was responsible for the automated filtering, processing and generation of the data described in this chapter.

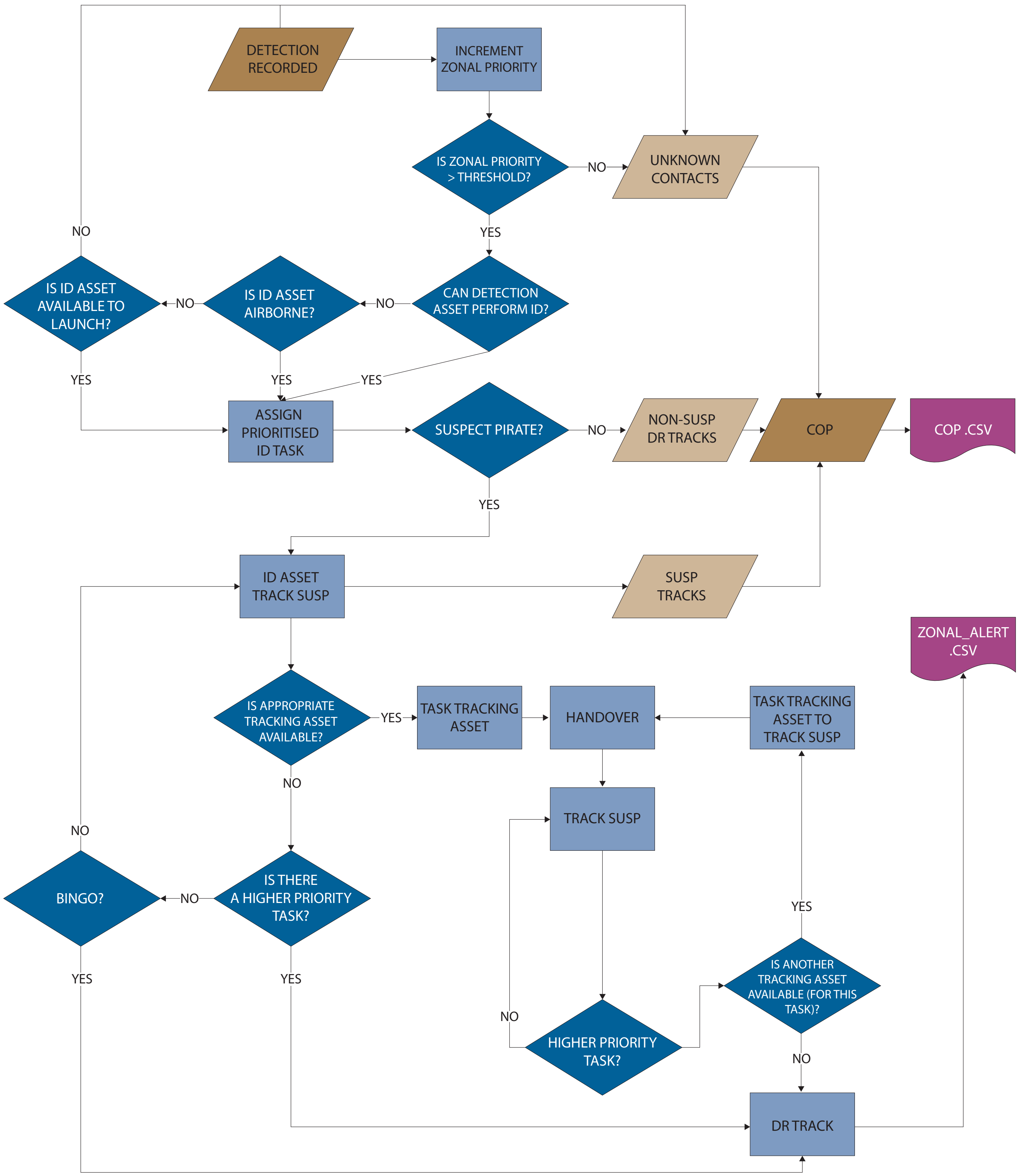


Figure 3-13: Asset Tasking Logic Flow Diagram.

3.17.2 Other applications were used to provide a visually immersive demonstration of the simulation operation, primarily to provide context during the experiment insights presentation.

Further details on the simulation components are shown in Table 3-2.

3.18 Metrics, Scenarios and Technical Requirements

3.18.1 The Operational Analysis (OA) staffs proposed key Measures of Effectiveness (MOE) and Measures of Performance (MOP) by which the experiment activity would be measured against. These were the following MOPs:

1. Detection Effectiveness
   - What percentage of Non-AIS traffic in the CP region is detected?

2. Identification Effectiveness
   - What percentages of tracked and non-tracked suspect pirates are identified?

3. Tracking Effectiveness
   - What is the Average Dropped Track rate in the steady state (suspect pirates/day)?

   - What percentage of dropped tracks (suspect pirate) are correctly re-identified within 24 hrs?

   - What is the Average percentage of Pirate Hours Tracked (suspect pirate) in the steady state?

3.18.2 With metrics confirmed, the detailed experiment design process was then executed. The key product of this work was the production of suitable, realistic and credible scenarios for both the blue and red force to operate in and the establishment of comprehensive technical requirements.

3.18.3 Note: suspect pirates are those targets that are simulated in the system as pirates at sea and are automatically identified as suspect pirates as they enter the field of 'view' of an ISR asset capable of identification.

A Dropped Track is a suspect pirate that can no longer be tracked because it enters port/exits the area of responsibility or because the ISR asset tracking it has reached bingo fuel, or has been ordered by the system to track another suspect pirate due to priority issues.

3.19 Experiment Execution

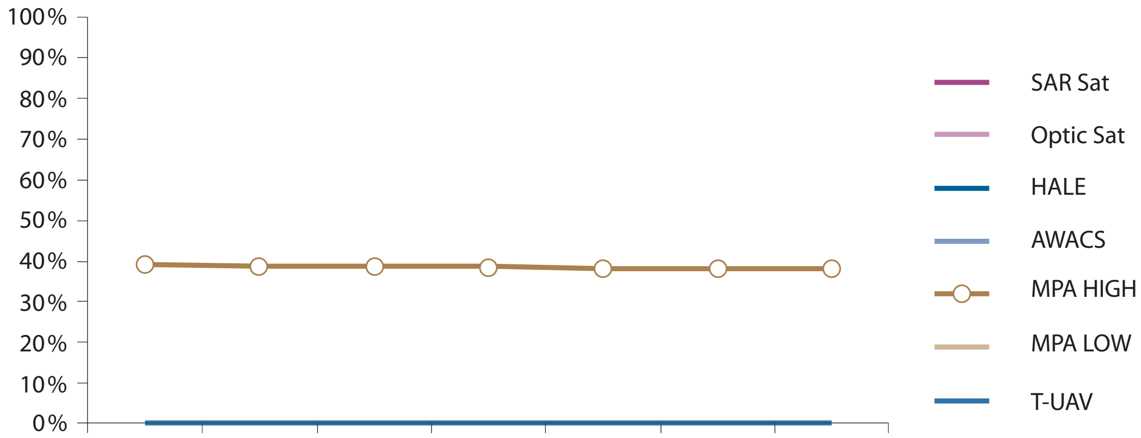
3.19.1 Software enabled data management and data mining followed analysis and visualisation and was used to auto-generate the measures to feed into the analysis process.

3.19.2 Individual log files were loaded and the agreed MOPs/MOEs were determined by analysing the data. The output was either data tables of selected information or graphs in various forms.

3.19.3 The experiment was developed to run over 21 days to ensure that the system achieved 'Steady State' (stage characterised by no significant change

Description	Primary Functions	Strengths
Constructive faster than real time simulation	Modelling simulated environment, platforms, behaviours & sensors	Scripting Simulation speed Adaptability
Analysis framework for MOP production	Generation of analysis metrics Providing detailed support to analysis	Clarity of picture Speed of metric extraction Flexibility to capture MOP metrics
3D virtual environment	Visualisations for scenario presentation	Visualisation

Table 3-2: OS2 Simulation Components Table.



Day	1	2	3	4	5	6	7
SAR Sat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Optic Sat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HALE	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
AWACS	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
MPA HIGH	39.4%	39.0%	38.9%	38.8%	38.2%	38.5%	38.2%
MPA LOW	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
T-UAV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 3–14: % of System, Non–AIS Traffic Detected by Platform, over 7 Days – Treatment A.

in MOEs/MOPs). In the event, it was observed that the 'Transitional Phase' (initial stage in which MOEs/MOPs build up to the 'Steady State') was completed much quicker than expected (2–4 days). Therefore the analysis was focused on the first seven days as there was little to be learned beyond that point.

3.20 Detection MOEs

3.20.1 In Treatment A, the only platform capable of detecting non-AIS traffic is the MPA (used wholly in the 'HIGH BOY' role).

Therefore, MPA 'High' detects 100% of all traffic detected by the system but, as seen in Figure 3-14, only detects an average of 38.7% of total system traffic. Therefore only 38.7% of traffic in the region is detected.

The transitional phase of the system is unobserved as the system achieves steady state within 24 hours.

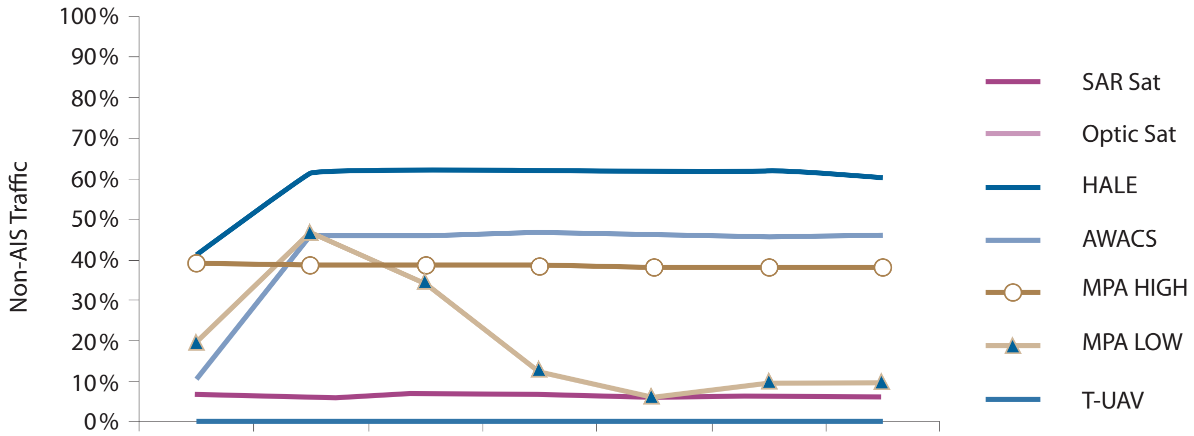
3.20.2 Treatment B (Figure 3-15, page 34) deploys all assets and clearly demonstrates the transitional phase.

Steady state (for 'HIGH BOYS') is established after 2 days. For the purposes of the experiment and the adopted CONOPS, the potential for optical satellites and TUAVs to detect new objects (see paragraphs 2.2.3, 2.4.5, 3.11.6) was not taken into account because of their limited detection capabilities.

Despite flying four times as many MPA 'High' sorties the detection value remains constant. They do not detect more of the system traffic than in Treatment A as they are still covering the same sea space and 'seeing' the same non-AIS traffic. They will likely contribute to the update rate of the COP.

The two passes of SAR Satellites only detect an average of 6.5% of whole system, non-AIS traffic.

MPA 'Low' detects a high percentage of whole system, non-AIS in the first 48 hours but appears to decrease markedly after 72 hours. There are only 2 MPA 'LOW BOY' sorties available per day and they cover completely different geographic areas on every sortie (unlike the 'HIGH BOYS').



Day	1	2	3	4	5	6	7
SAR Sat	7.0%	6.5%	6.6%	6.8%	5.8%	6.6%	6.5%
Optic Sat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HALE	41.6%	61.7%	62.2%	62.4%	61.5%	62.7%	60.6%
AWACS	10.8%	46.5%	46.2%	46.3%	46.7%	46.2%	45.8%
MPA HIGH	39.4%	39.0%	38.9%	38.8%	38.2%	38.5%	38.2%
MPA LOW	20.3%	47.4%	34.9%	13.0%	6.7%	10.3%	10.3%
T-UAV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 3-15: % of System, Non-AIS Traffic Detected by Platform, over 7 Days – Treatment B.

This would likely result in a random number of detections per day. Therefore the apparent decrease in detections may be an anomaly.

3.20.3 Treatment C (Figure 3-16, page 35), deploys all assets and appears to achieve steady state very rapidly. This is likely due to the increase in sortie commitment. Again (see paragraph 3.20.2), the potential for optical satellites and TUAVs to detect new objects was not taken into account.

The MPA 'High' sorties detection figure remains approximately constant (as expected given the same area) though COP detection updates will increase.

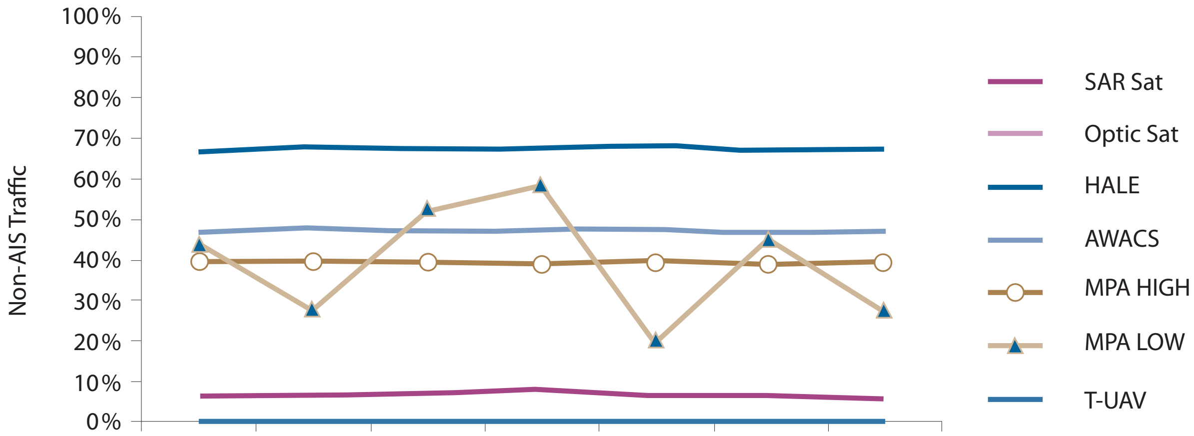
Despite doubling the number of SAR satellite passes to 4, they cover a similar area, and still only detect an average of 6.3 % of whole system, non-AIS traffic.

At times, 'LOW BOY' MPAs detect a very high percentage of whole system, non-AIS traffic but the levels appear very inconsistent. There are 8 'LOW BOY' MPA sorties available per day in Treatment C and this increase in sorties may contribute to the increased randomness observed in the numbers of detections.

3.20.4 Treatment D (Figure 3-17, page 36), deploys all assets and also appears to achieve steady state very rapidly. Again, this is likely due to the high numbers of detection assets available.

Optical satellites and TUAVs do not have 'Detection' capability.

Most platform sortie detection figures remain approximately constant with the exception once again



Day	1	2	3	4	5	6	7
SAR Sat	5.8%	5.9%	6.3%	7.3%	6.3%	6.3%	5.5%
Optic Sat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HALE	66.6%	67.9%	67.6%	67.3%	68.3%	67.2%	67.2%
AWACS	46.5%	47.4%	47.1%	47.1%	47.1%	46.6%	46.9%
MPA HIGH	39.3%	39.5%	39.3%	38.7%	39.5%	38.9%	39.3%
MPA LOW	44.0%	27.6%	52.2%	58.8%	19.5%	45.4%	27.3%
T-UAV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 3–16: % of System, Non–AIS Traffic Detected by Platform, over 7 Days – Treatment C.

of the MPA ('LOW BOY') which varies significantly and continue to demonstrate random behaviour as expected by random tasking. Also, the SAR Sat figures now appear to fluctuate. This is likely due to more area being covered by more than doubling the number of passes to 9.

3.21 Identification MOEs

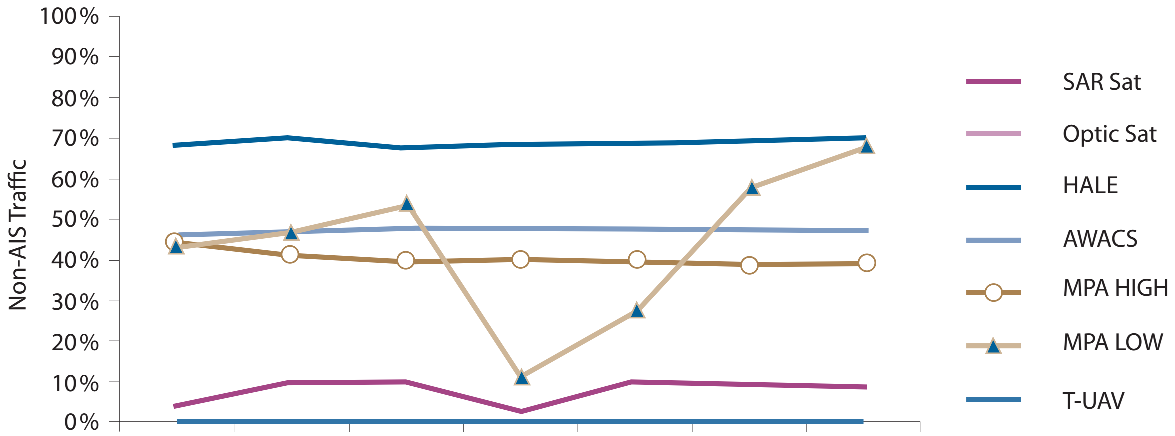
3.21.1 Figures 3-18 through 3-21 show Identifications of suspect pirates by Treatment.

3.21.2 There is only one HIGH BOY MPA available for Identification tasking in Treatment A (Figure 3-18, page 37). In Treatment B (Figure 3-19, page 37), there is one HALE, two HIGH BOY MPAs, and two LOW BOY MPAs. The increase in daily Identification rate of 47.8 percentage points is impressive and most likely results from the fact that, it becomes possible to surveil the entire region with the inclusion of the HALE asset.

3.21.3 In Treatment C (Figure 3-20, page 38) the available asset sorties are approximately doubled but the average identification rate only increases by 16.3 percentage points. In Treatment D (Figure 3-21, page 38) the sorties are doubled again, resulting in an increase of just 1.5 percentage points.

3.22 Tracking MOEs

3.22.1 Long term tracking of suspect pirates is a task carried out exclusively by TUAVs. Results can therefore be easily presented and considered across treatments.



Day	1	2	3	4	5	6	7
SAR Sat	3.8%	9.4%	9.5%	3.0%	10.0%	9.4%	8.3%
Optic Sat	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
HALE	69.1%	70.6%	68.8%	69.0%	69.6%	69.7%	70.4%
AWACS	46.6%	47.3%	48.1%	47.6%	47.6%	48.1%	47.7%
MPA HIGH	44.6%	42.2%	40.2%	40.2%	40.3%	39.7%	39.7%
MPA LOW	44.2%	47.5%	54.8%	11.3%	28.1%	58.6%	69.0%
T-UAV	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Figure 3-17: % of System, Non-AIS Traffic Detected by Platform, over 7 Days – Treatment D.

3.22.2 The graph at Figure 3-22, page 39 illustrates how an increase in TUAV assets provides improvement in the numbers of pirate hours tracked (Pirate Hours = Number of pirates at sea, multiplied by the number of hours they spend at sea, within a 24 hour period).

3.22.3 It is interesting to note that the Treatment D commitment level (16 x TUAV sorties) is very similar to the average of 18 pirates at sea on any given day. As one or two of these pirates are usually transiting outside of the OS2 region of responsibility (and therefore not included in the metric) it may be inferred that, given as many (or more) tracking assets as targets, the percentage of pirate hours tracked would tend towards 100 %. This can be observed at Figure 3-22 as Treatment D achieves 93.6 % of all available pirate hours tracked. However, it is likely that having equal numbers of tracking sorties to pirates at sea will still not quite achieve 100 % due to transit times of TUAVs.

3.22.4 Taking the percentage of pirate hours being tracked in the steady state (Day 7) across all treatments; a clear exponential increase is discernible (see Figure 3-23, page 40).

3.22.5 Numbers of tracking asset sorties, like all other assets, approximately double with each treatment, i.e. sortie numbers increase exponentially also (see Figure 3-24, page 40).

3.22.6 These graphs suggest that tracking assets (with 24 hour endurance) are constantly employed (as would be expected) while there are more or similar numbers of targets than asset sorties available. This adds to the

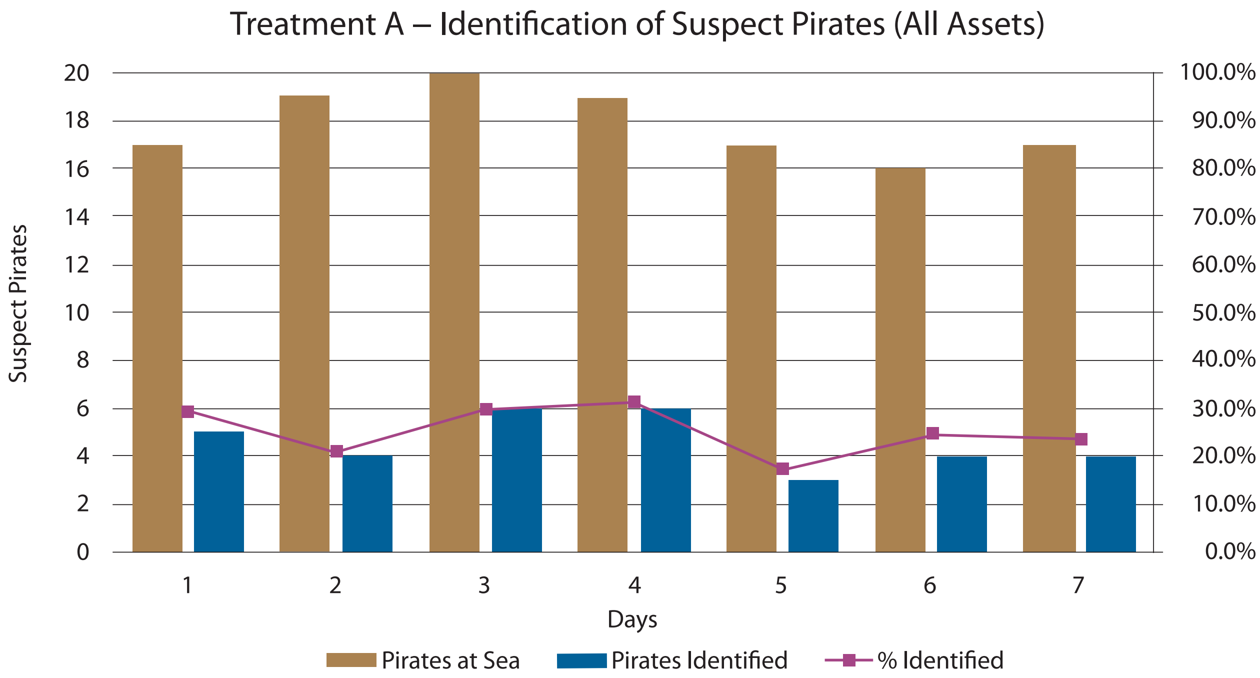


Figure 3-18: Treatment A – System Identifications of suspect pirates, by day.

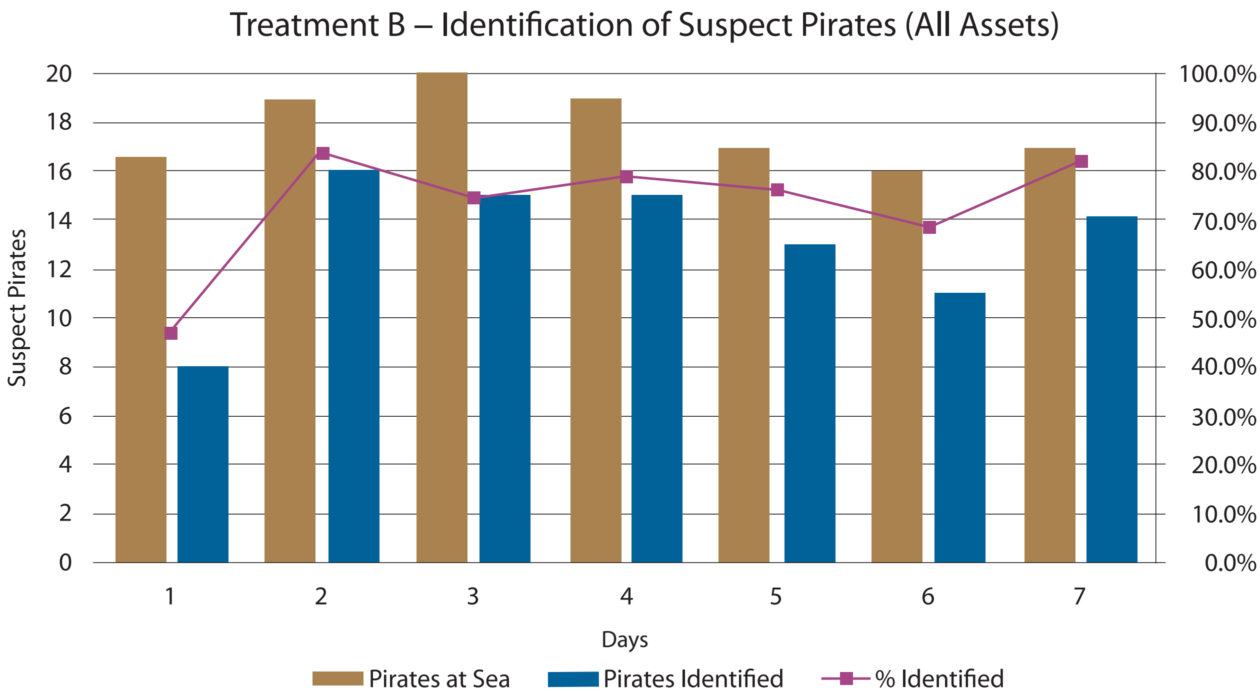


Figure 3-19: Treatment B – System Identifications of suspect pirates, by day.

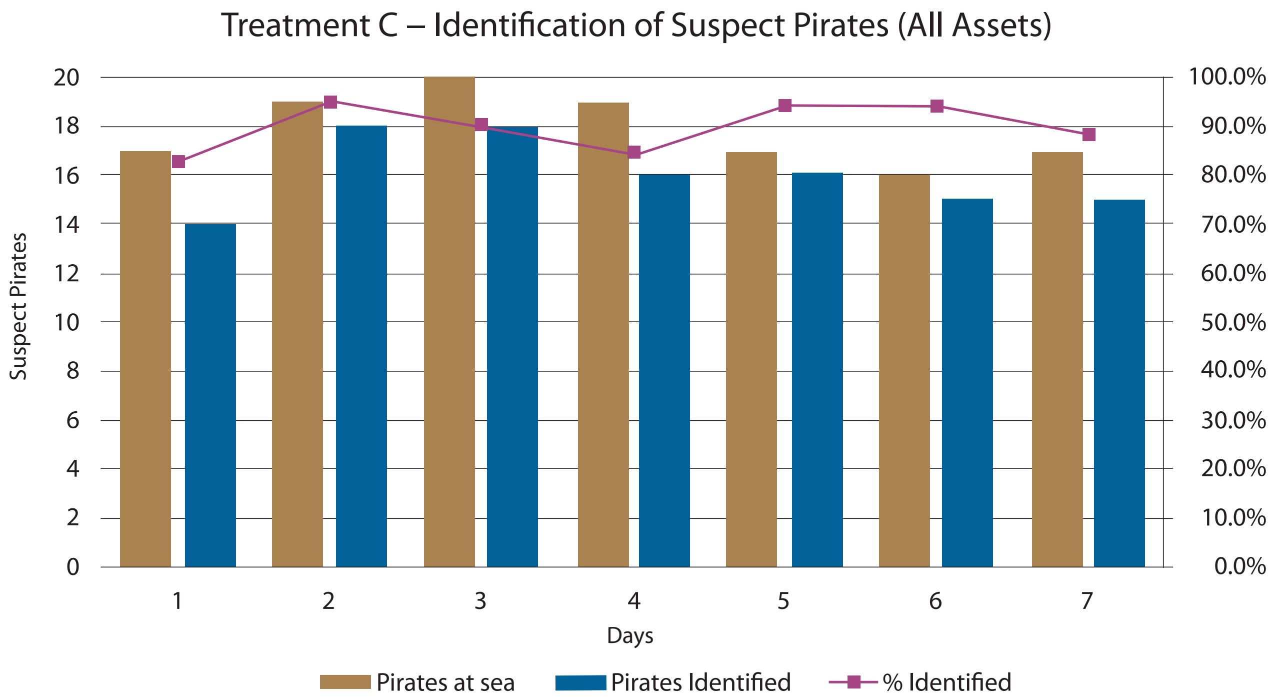


Figure 3-20: Treatment C – System Identifications of suspect pirates, by Day.

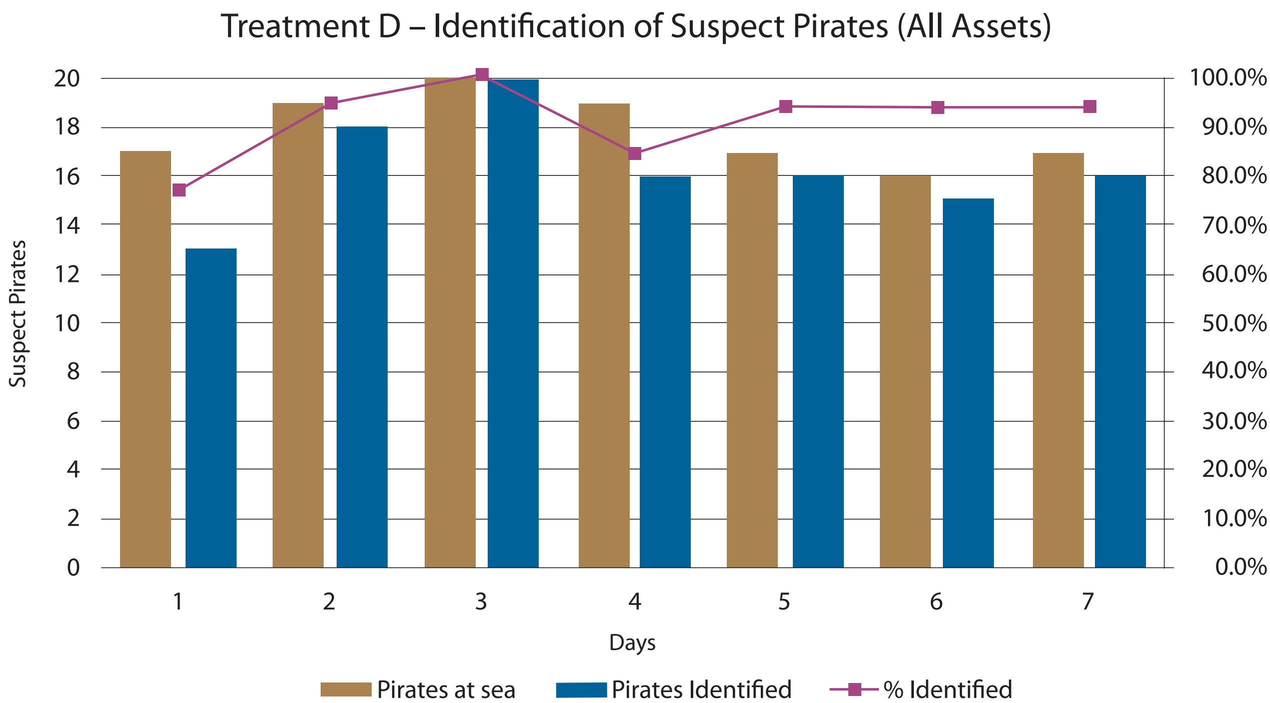


Figure 3-21: Treatment D – System Identifications of suspect pirates, by Day.

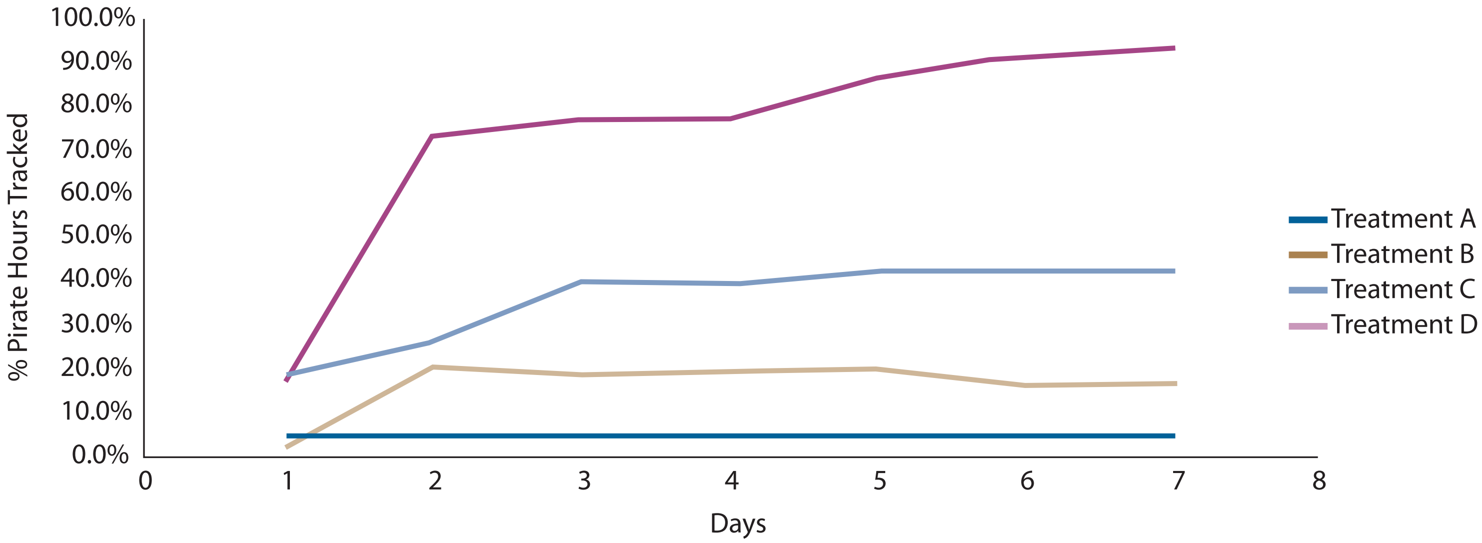


Figure 3-22: % of Pirate Hours at Sea, Tracked by the System, by Day, all Treatments.

evidence supporting the premise that tracking asset requirements likely coincide with the number of targets to be tracked.

3.22.7 Figure 3-25, page 41, shows the number of Dropped Tracks (suspect pirate). Intuition would suggest that numbers of Dropped Tracks would decrease with sortie commitment level. At first glance, Figure 3-25 appears to follow this hypothesis. However it must be noted that this graph does not represent a Dropped Track Rate, but rather just a tally, and after a brief transitional phase, the picture becomes more confused.

3.22.8 Numbers of Dropped Tracks by treatment converge and cross suggesting that a statistically significant 'steady state' is not observable. The low numbers of Dropped Tracks make it difficult to perceive any particular trend (especially in low Treatment sets). However examining Treatment D, the Dropped Track appears to gradually increase. This could be due to the hypothesis of pirates transiting outside of the OS2 region of responsibility and the fact that TUAVs cannot achieve 24 hour tracking due to transit times. Also, by Day 5 the majority of suspect pirates that may be tracked, are being tracked and it becomes inevitable that more tracks will be dropped than when only few of the targets were being followed.

3.22.9 Figure 3-26, page 41, shows the number of dropped suspect pirate tracks which are then reacquired within 24 hours. Similar to Figure 3-25, the data set does not appear to present any obvious insights into system behaviour.

3.23 INSIGHT 1: SAR Satellite Contribution to Detections

3.23.1 The SAR satellite detection percentage contribution was defined from the number of unique non-AIS contacts detected by SAR Satellites (not detected by any other platform) over the total unique system detections in a 24 hour period.

3.23.2 All detections were grouped into their corresponding 24 hour period of occurrence. These were then plotted to show the total number of detections per 24 hour period and compared by treatment.

3.23.3 The key insights identified during the experiment were the following.

- SAR satellites appear to contribute little to overall system detections (approximately 6% of unique detections per 24 hrs). This holds true for all treatments employing SAR satellites (i.e. B-D) and suggests a near static relationship between force mix

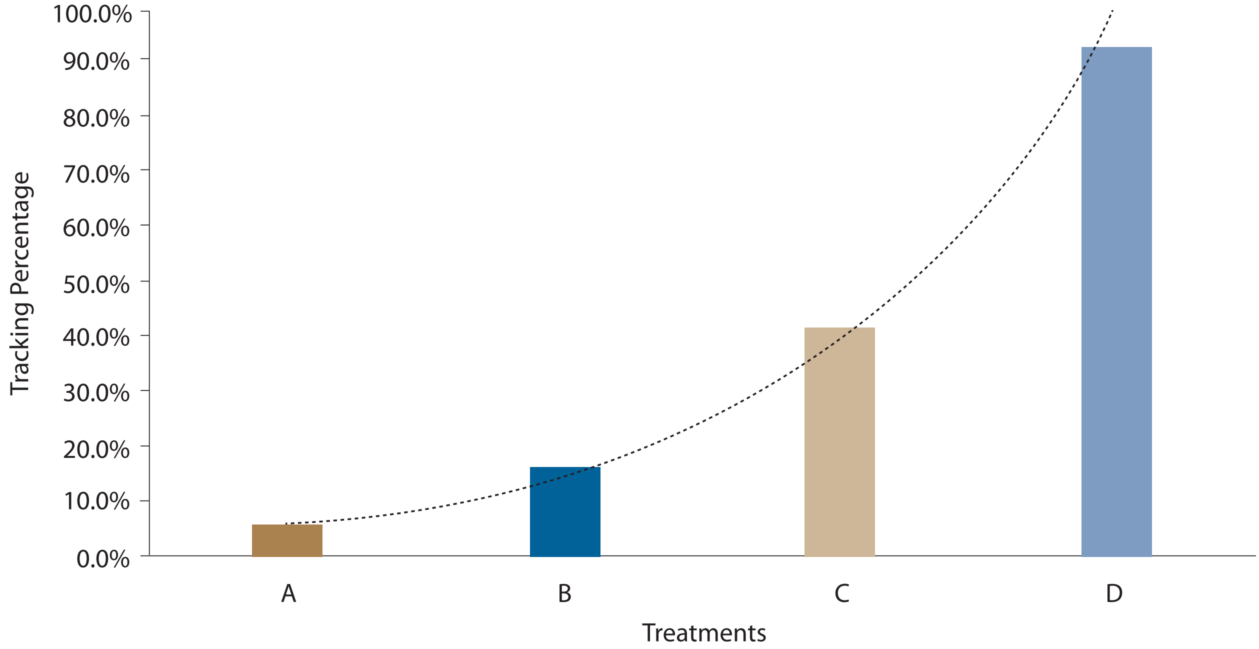


Figure 3-23: Exponential Increase in Tracking of Pirates, in the Steady State, by Treatment.

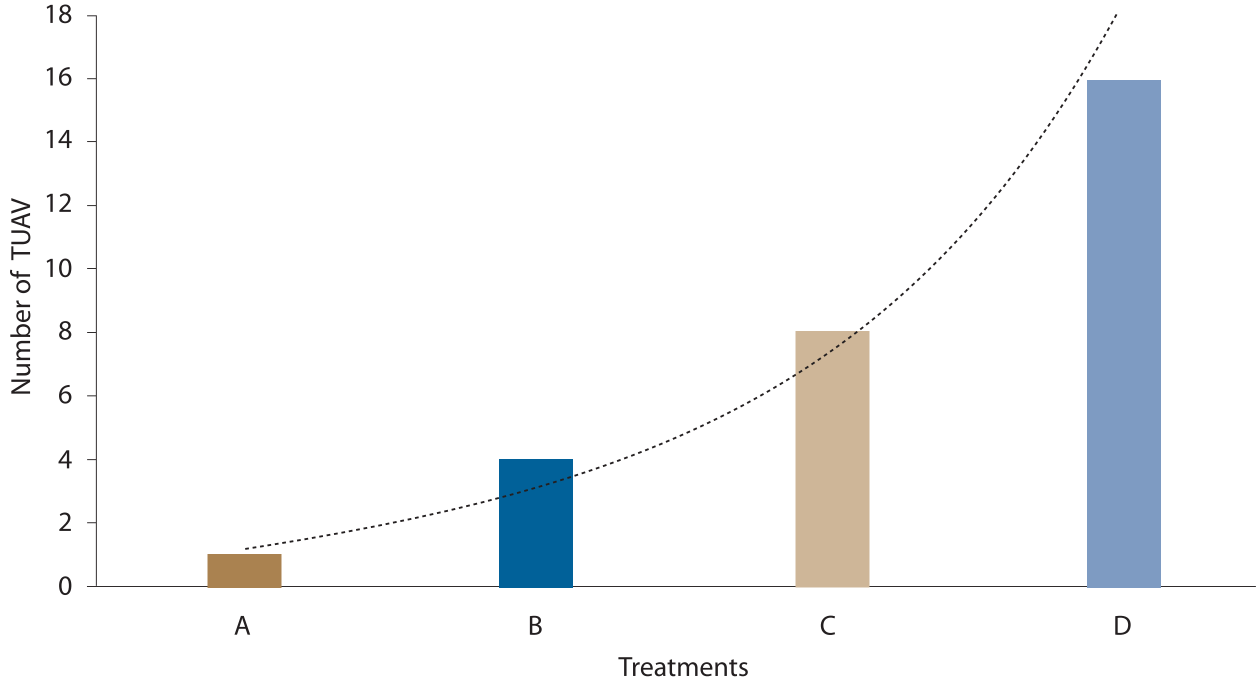


Figure 3-24: Exponential Increase in Tracking of Pirates, in the Steady State, by Treatment.

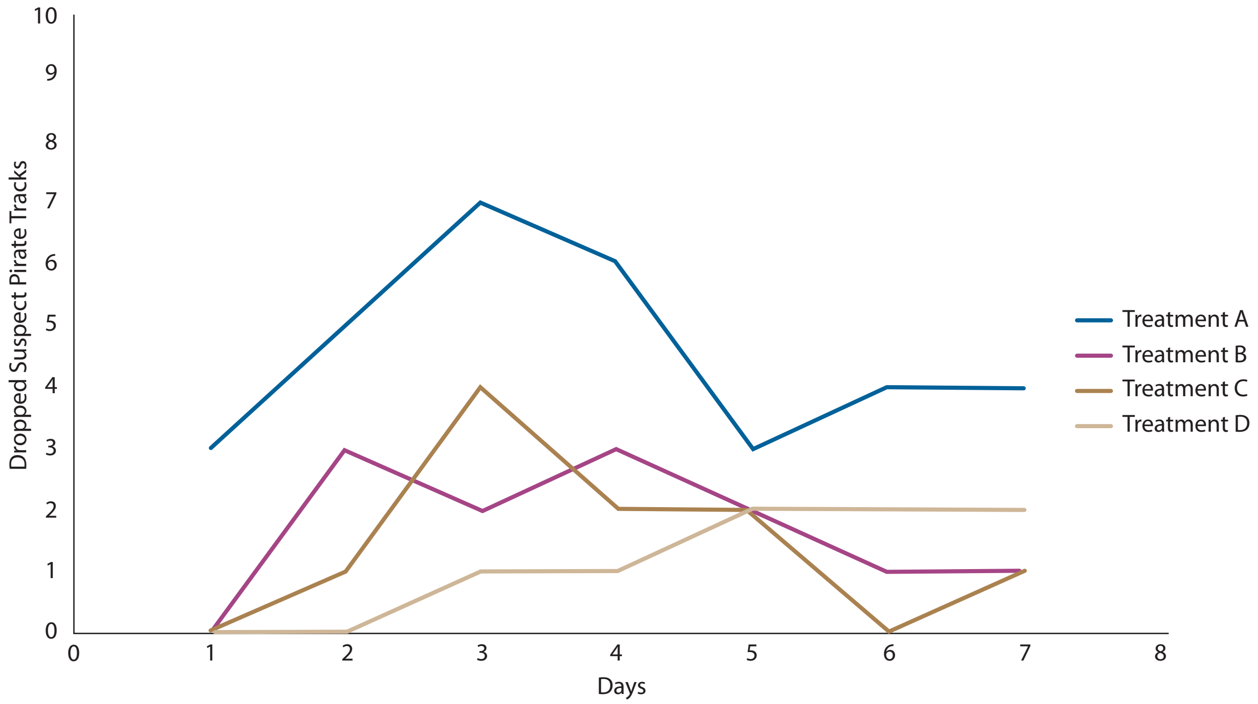


Figure 3-25: Number of Dropped Tracks (suspect pirate) by the System, by Day, all Treatments.

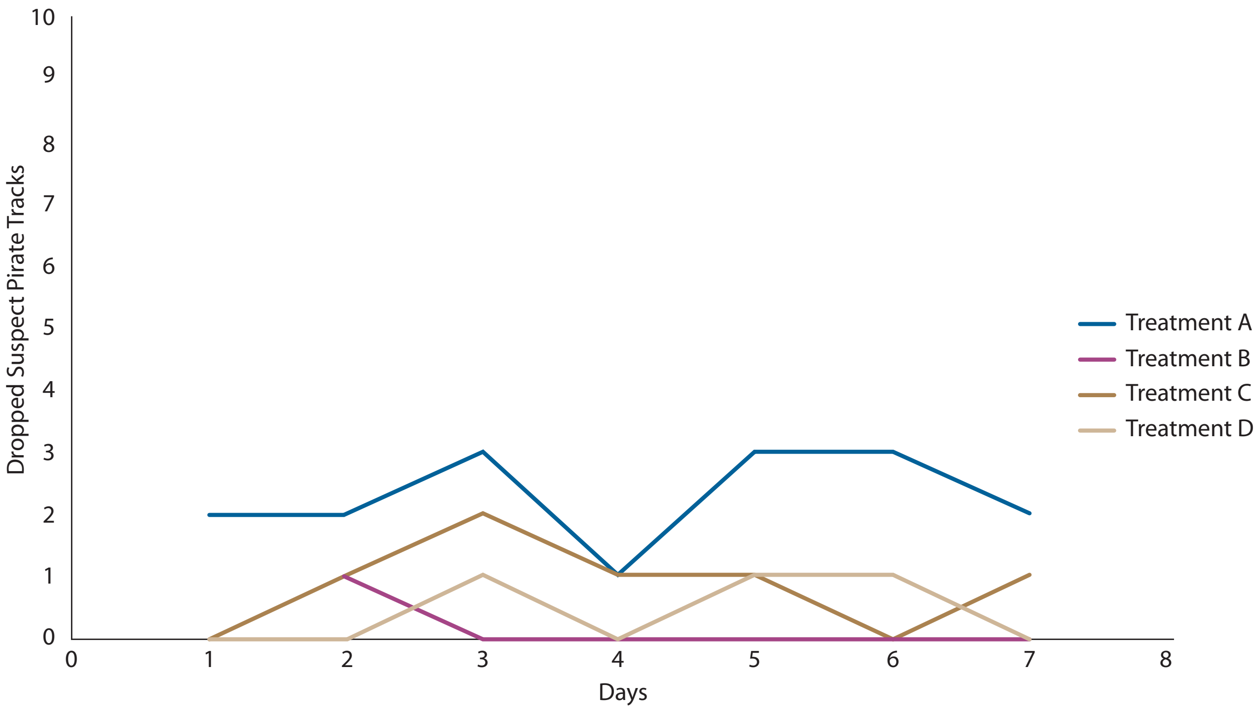


Figure 3-26: Number of Dropped Tracks (suspect pirate) Re-Identified by the System within 24 Hrs, by Day, all Treatments.

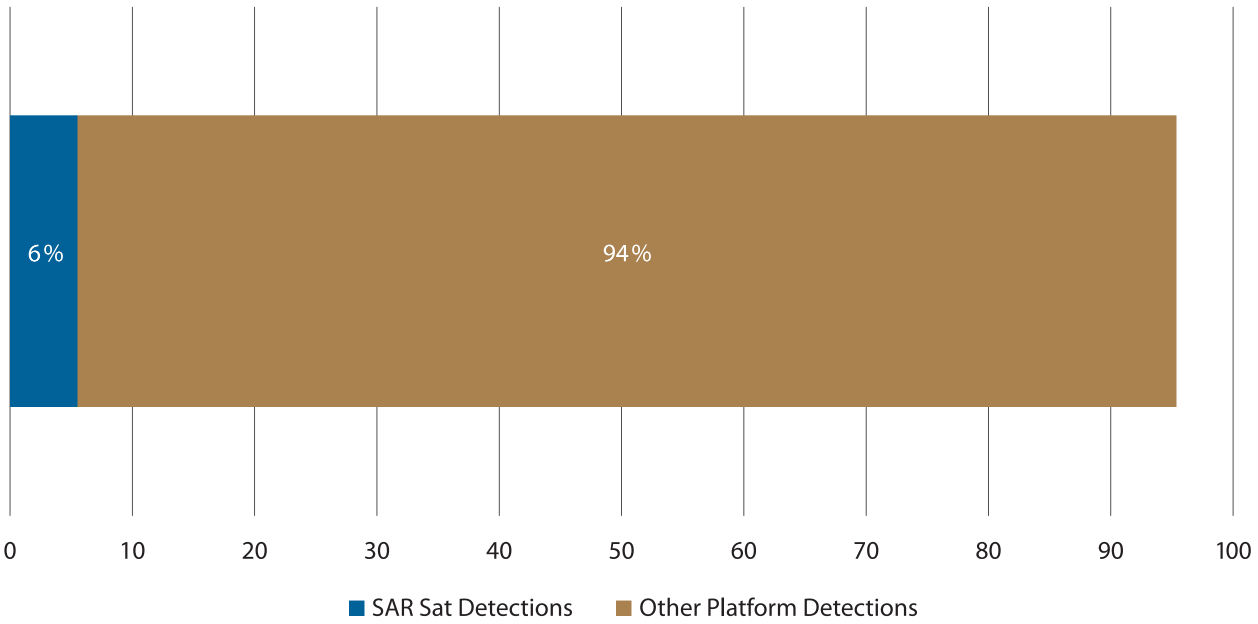


Figure 3–27: Treatment D – Avg % Contribution to Unique Detections, by SAR Satellite (24 Hrs).

ratios and platform contribution to system detections in Treatments B-D. In Treatment A, no SAR satellites were used.

- SAR satellites' detection appears relatively infrequently at the force mix levels studied and mainly cover areas already surveilled by more capable HIGH BOY assets. This data would also likely be time delayed due to collection, transmission, processing and integration.

- The SAR satellite surveillance area is approximately equivalent to 4 hours of LOW BOY MPA patrol at 1,000 ft, but unlike the LOW BOY MPA, SAR satellites have no identification capability.

- If Treatment D levels of commitment to SAR satellite products (9 passes per day) were applied to Treatment A, SAR Sat would still only provide 12% of unique system detections.

3.23.4 The graph in Figure 3-27 shows unique system detections in 24 hrs along the horizontal axis. It clearly illustrates that SAR satellite detections account for just 6% of over 900 system detections.

3.24 INSIGHT 2: Low Boy MPA Contribution to COP Detections

3.24.1 The LOW BOY MPA detection percentage contribution was defined from the total number non-AIS contacts detected by LOW BOY MPAs in a 24 hour period. As these contacts may also have been detected by other platforms, the LOW BOY MPA may contribute both new unique tracks and update tracks already held in the COP system.

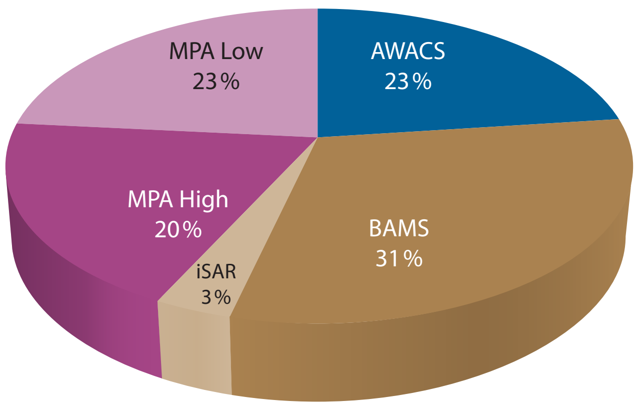


Figure 3-28: Treatment B, Day 2 – Avg % Contribution to COP Detections, by Platform (24 Hrs).

3.24.2 All detections were grouped into their corresponding 24 hour period of occurrence. These were then plotted to show the total number of detections per 24 hour period and compared by treatment (Figure 3-28).

3.24.3 The key insights identified during the experiment were the following:

- In the transitional phase, LOW BOY MPAs often provide 23 % of COP detections in the course of their reactive tasking. These detections were achieved, not on scheduled routes but whilst travelling between and searching priority zones.

- LOW BOY MPAs appear to contribute approximately the same contact detections as AWACS and HIGH BOY MPAs. This figure was comparable throughout Treatments B-D.

- LOW BOY MPAs provide few unique detections, as they tend to cover areas already surveilled by HIGH BOYS, but do help provide a timely COP.

3.25 INSIGHT 3: System Identification of Suspect Pirates

3.25.1 System identification was defined as the percentage of total suspect pirates at sea identified by the combined identification assets available in a 24 hour period.

3.25.2 All identifications of suspect pirates were grouped into their corresponding 24 hour period of occurrence. These were then plotted to show the total number of identifications per 24 hour period and compared by treatment.

3.25.3 The key insights identified during the experiment were the following:

- It could be considered that with the limited assets available in Treatment A (1 MPA and 1 TUAV), they provide an average daily identification rate of 25.5 %.

- Between Treatment A and B the number of suspect pirates identified in a 24 hour period, increases significantly by 47.8 percentage points. This is most likely due to the fact that Treatment B commitment levels allow surveillance of the entire region, as opposed to Treatment A where it was only possible to cover the BAM and GoA within 24 hours.

- Treatment B appears to provide a substantial average daily identification rate of 73.3 %.

3.25.4 The graphs illustrated in Figure 3-29, page 44, show the number of simulated days along the horizontal axis and the number of suspect pirates active that day are plotted on the left vertical axis and represented by bars (Brown = Total suspect pirates, Blue = Identified suspect pirates). The % of identified suspect pirates that day are plotted on the right vertical axis and represented by the purple line.

- Examination of a plot of average daily identification rates of suspect pirates by Treatment suggests a 'Law of Diminishing Returns'.

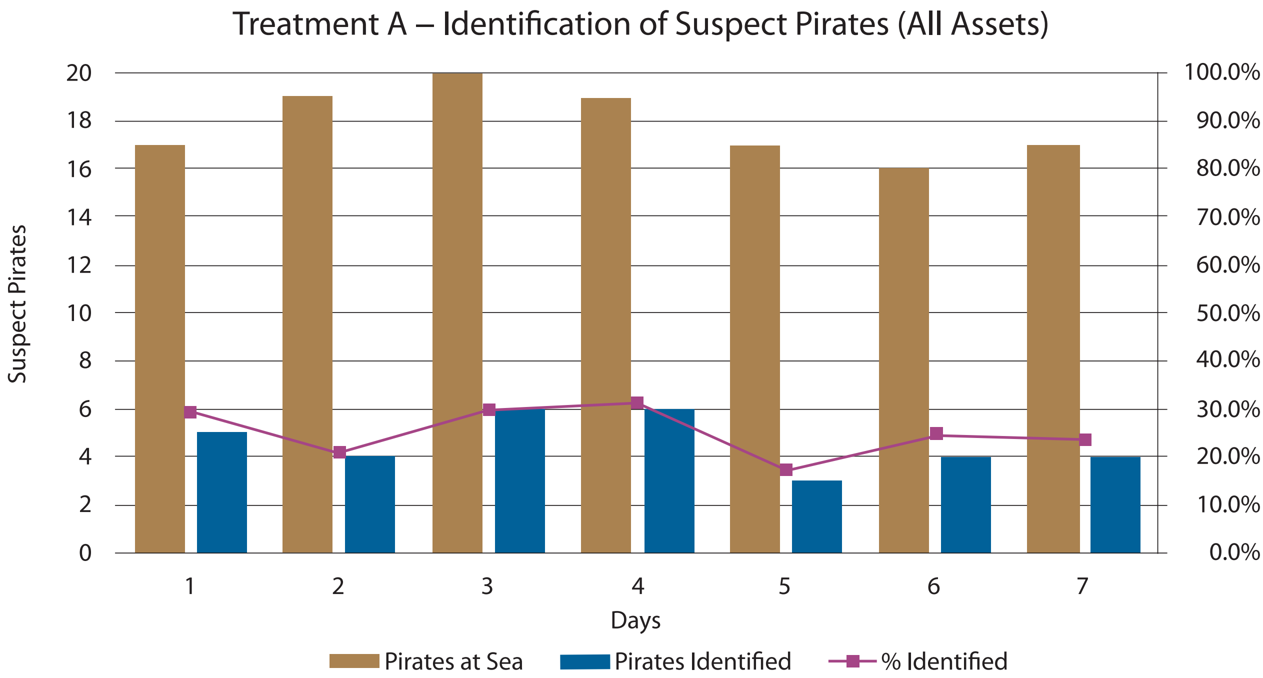
- The most significant increase in average daily identification rates is observed between Treatments A and B.

- Despite asset numbers consecutively doubling through Treatments B-D, there is little significant increase in identification rates.

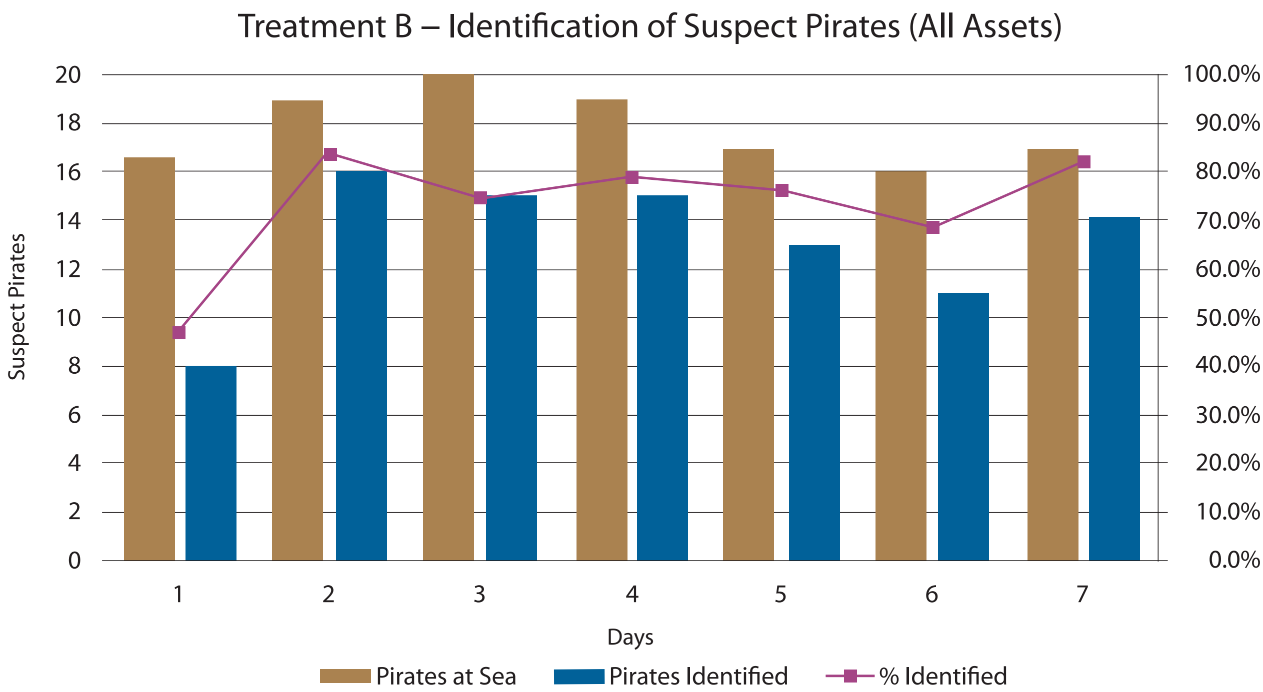
- These results suggest numbers of identification capable assets may be acceptably sufficient at Treatment B commitment levels.

- The high identification rate also suggests that dropped tracks would not present a large concern as any dropped tracks would likely be re-identified within 24 hours.

3.25.5 The graph at Figure 3-30, page 45, shows Treatments on the horizontal axis and the average percentage of suspect pirates identified by the system in a 24 hour period on the vertical axis. A 'Law of Diminishing Returns' can clearly be observed as the identification rate only increases by 17.8 percentage points



Average Daily Identification Rate = 25.5 %



Average Daily Identification Rate = 73.3 %

Figure 3–29: Treatments A and B Comparison – Avg % System IDs of suspect pirates (24 Hrs).

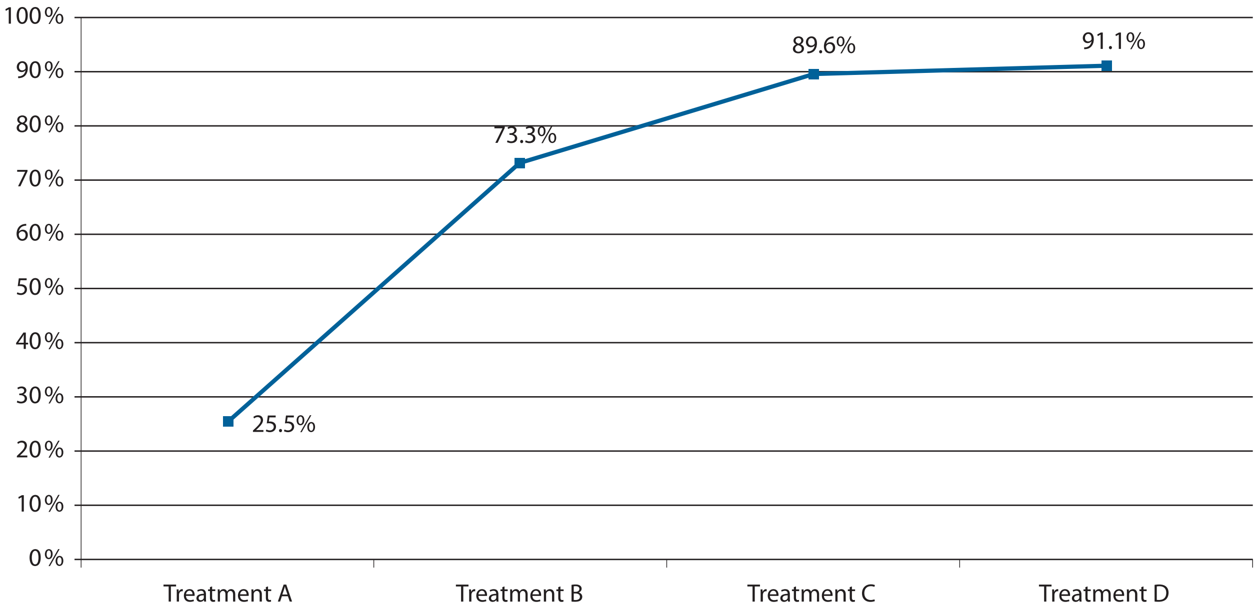


Figure 3-30: Plot of Avg Daily System ID Rates of suspect pirates by Treatment (24 Hrs).

between Treatments B and D, despite Treatment D asset commitment being approximately 400% greater. Treatment B Identification sortie commitment levels may be acceptable for the task.

3.26 INSIGHT 4: Detection & Identification Assets vs. Tracking Assets

3.26.1 Detection and Identification assets are primarily driven by the scheduled flying programme and operate in the 'HIGH BOY' mode. The exception to this rule is the 'LOW BOY' MPAs. Tracking assets are only tasked once a suspect pirate has been identified.

3.26.2 All detections, identifications and tracking tasks were grouped into their corresponding 24 hour period of occurrence. These were then plotted to show the total number of events per 24 hour period and compared by treatment.

3.26.3 The key insights identified during the experiment were the following:

- The 'LOW BOY' MPAs re-cover area already surveilled by 'HIGH BOY' assets and therefore makes little contribution to unique detections and identifications (though as seen in INSIGHT 2 it does provide significant contribution to the COP).

- It may be useful to consider the experiment problem in two ways: first, calculating the resources required providing identifications of targets, and second, the resources required to provide persistent tracking of targets.

- For Identification, much of current MPA doctrine would likely suffice, and for OS2 the Detection and Identification asset commitment considered in Treatment B are likely to be sufficient.

- For Tracking, an accurate assessment of the number of targets is likely to be the most important factor. For OS2 the Tracking asset commitment considered in Treatment D provides the greatest tracking efficiency.

3.27 Conclusions

3.27.1 Detection

In experiment OS2, SAR satellites are employed as detection assets. It would appear that considerably more SAR satellite passes would be required to make a significant contribution to the COP if air breathing

ISR assets were also available. If asset commitment was reduced in the 'Steady State', SAR satellites would likely be even less effective due to an increased requirement for MDA to be more timely in order to quickly task identification and tracking assets before contacts were lost.

In light of these considerations, the most efficient way to employ SAR satellites might be similar to EO/IR satellites: the investigation of targets that are already under observation or that might be of importance based on intelligence information provided by other means (local authorities, air breathing assets, surface assets, etc.). These known locations can be ashore (i.e. pirates' bases and camps, surface lines of communications, defence installations) or at sea (i.e. hijacked ships steaming or anchored, mother ships or skiffs along SLOC).

It is also worth mentioning that the availability of military satellites (not included in the experiment) would increase the number of satellite products, resulting in an improvement in detection.

3.27.2 Identification

Despite asset numbers consecutively doubling through Treatments B-D, there is little significant increase in identification rates. These results suggest numbers of identification capable assets may be acceptably sufficient at Treatment B commitment levels. This is a very significant finding, especially for planning purposes, but the model is highly sensitive to the assumptions made regarding the identification capability. In particular, the simulation runs on the supposition that once a detected vessel enters the field of 'view' of an asset, it is automatically identified as a suspect pirate if it is seen as a pirate by the system. This means that misidentifications that did not take place in OS2 could occur in actual operations.

If the detection, identification and tracking of suspect pirates in the CP region are considered a 'Cueing System', it is clear that the population of untracked suspect pirates is likely to decrease as the system transitions to a 'Steady State'. If suspect pirate numbers remain steady, then fewer resources may be required to carry out identification as potentially most suspect pirates would be constantly tracked. This would present fewer new identification opportunities to the system. These new identifications would likely be most easily established in the littoral region as suspect pirates put to sea. Therefore, in the 'Steady State' it may only be necessary to fly regularly scheduled patrols off the coastline, rather than the entire area of operations. This could considerably reduce the asset commitment required in the 'Steady State', which translates into fewer sorties required per day.

LOW BOY MPA tasking improves COP update rate and may also provide some incidental identification of 'Targets of Opportunity' in the course of routing to and from their primary area of operation. This would likely decrease in the steady state because the majority of targets are already being tracked, but could still slightly increase the efficiency of the 'Steady State' system.

Also HIGH BOY assets with identification capability such as HALE UAS and HIGH BOY MPAs appear extremely effective and contribute greatly to suspect pirate 'Identifications of Opportunity' in the course of their patrols of scheduled routes.

3.27.3 Tracking

In CP operations at sea, the tracking effectiveness is as relevant as the identification effectiveness. Only the ability to track suspect pirates allows the issuing of warnings to close sailing merchant vessels or direction of the nearest capable surface asset to conduct an inspection (this would also drive down the number of targets that need to be tracked). However, the problem of tracking should be considered separate from the problem of identification, as the relevant asset requirements depend on different variables.

The daily identification rate is likely to be acceptable at low commitment levels even in the system transitional phase and it is likely that most, if not all, suspect pirates will be identified within the first few days. As highlighted in OS2, Treatment B could be sufficient in terms of identification performance. On the other hand, Treatment D seems to provide the greatest tracking efficiency; hence the greatest requirement will likely be for persistent tracking assets, even if the dropped track rate might appear to be of little concern, based on the likely high daily identification rate of the system.

Following the experiment philosophy, the number of tracking assets must be calculated based on known or expected numbers of suspect pirates operating in the region. Unfortunately in actual scenarios, this option is either unrealistic or highly difficult to predict.

Another way to increase the degree of persistent tracking could be to employ detection and identification assets (HALE UAS, AWACS, HIGH BOY MPAs) also as tracking assets.

Depending on the priority defined by tactical commanders, these assets could stop their patrol route and provide persistent tracking of suspect pirates of high relevance, such as pirates along SLOC or near merchant vessels, improving the overall tracking effectiveness of the force mix. However, the rate of detection and identification might be affected if this method is used.

1. **CAVOK** is an abbreviation for **C**eiling **A**nd **V**isibility **OK**ay, indicating no clouds below 5,000 ft (1,500 m) or the highest minimum sector altitude and no cumulonimbus or towering cumulus at any level, a visibility of 10 Km (6 mi) or more and no significant weather.

"End Piracy Now" banner on MSC Savona in Port of Felixstowe.

CHAPTER IV

Areas of Concern and Recommendations

4.1 Introduction

This chapter contains recommendations identified by areas of concern. Recommendations were derived both from the experiment described in Chapter III and the findings of JAPCC SMEs research for the development of this paper.

Each recommendation or set of recommendations is preceded by a rationale.

4.2 A&S Contribution to CP Operations

Rationale

The creation and sustainment of maritime security is essential to mitigating threats short of war, including piracy, terrorism, weapons proliferation, drug trafficking, and other illegal or illicit activities. Countering these threats in distant regions of the world protects our homelands, enhances global stability and secures freedom of navigation for all nations.

Somali piracy is a local problem with regional reach and global impact. Being the only growth industry in

a region of failed states and shattered economies, this form of criminal activity is expected to undermine the rule of law at sea and become more profound in a shrinking world economy. The overall response by the international community has been, to a certain extent, successful but not decisive. The final solution to piracy rests ashore. However, this solution might take years and efforts at sea are still required to provide the necessary time for onshore initiatives (including military kinetic actions) to succeed in ending piracy. NATO must encourage member nations to share national capabilities for the benefit of all, play to its proven strengths of coordinated operations and take a strong stance against duplication of effort.

Recommendation

NATO nations should acknowledge the risks involved with piracy and be aware of the importance of their engagement in the fight against this criminal activity with a truly comprehensive approach.

4.3 Force Generation

Rationale

In CP operations, warships with organic air capabilities are the 'end game' assets but a persistent tool in support of maritime forces is needed to fill the asymmetry gap to combat pirates' successful tactics.

Combined force packaging is commonly accepted as the mechanism most likely to result in an effectively balanced joint force. Expanding the operational thinking for CP, commanders need a combined force package that includes surface vessels, manned aircraft, unmanned aircraft, and space support.

The experiment hints that the current intermittent employment of A&S assets should be more engaged in CP operations, delivering the best available ISR capabilities, as part of the overall military effort to contain and disrupt Somali piracy. However, force generation should take into account specific capability requirements.

Experiment OS2 proves to a certain extent that specific A&S capabilities required for the enhancement of MSA in the CP mission are:

- Space-based AIS for improved situational awareness of non-AIS traffic;
- Space-based SAR and EO/IR capabilities for the investigation of known locations at sea or ashore;
- High Altitude, persistent, manned assets equipped with radar for detection (AWACS);
- High Altitude, persistent, unmanned assets equipped with radar, EO/IR for detection and identification (HALE UAS);

- Medium/Low Altitude, persistent, manned assets equipped with radar, EO/IR, optical for detection identification and tracking (MPA);

- Low Altitude, persistent, unmanned assets equipped with radar, EO/IR, optical tracking (TUAV) capabilities.

It is worth mentioning that these capabilities are to be considered interconnected. In other words, only the right mix of assets delivering these capabilities would provide the desired effects and relevantly contribute to MSA.

Another issue identified in the main OS2 experiment (insight 3) shows that the increase in effectiveness in identification of pirate vessels is not directly proportional to an increase in A&S assets. The absence of a linear function in the quantity-efficacy relationship means that simply piling up platforms does not deliver the necessary ISR support.

Recommendation
Force generation of A&S assets in CP operations should aim at providing the right mix of forces based on capability requirements rather than simply increasing the total number of platforms.

4.4 Basing

Rationale

Air support is critical for the success of CP operations. The relatively non-permissive land environment of Somalia and, to a lesser degree, Yemen and the associated force protection requirements that result offer significant challenges when selecting operating bases for both manned and unmanned aircraft.

Djibouti in the Gulf of Aden, and either the Seychelles or Kenya in the Somali Basin, offer viable basing options. However, they also require long transit flights to the deep ocean operating areas with correspondingly short on-station times. Air-to-Air Refuelling (AAR) would improve AWACS patrol times, and therefore, offer better resolution to planning and execution of associated MPA support missions, in most cases eliminating the need for additional AAR support.

Recommendation
High endurance air assets to include shipborne UAS systems are the preferred solution to overcome limitations in basing options.

4.5 Command and Control

Rationale

Somali Piracy is an international problem and requires an international solution. There is no single multinational organisation or coalition that can provide a solution to this maritime security problem. A global maritime partnership that unites naval forces would increase overall capabilities, such as response time, agility and adaptability to provide an effective response to piracy.

The multi-layered ISR CONOPS described in Chapter II could be integrated with platforms from different coalitions (NATO, EU and CMF) and non-aligned nations (Australia, India, Japan and Russia, among others).

Unfortunately, this could generate a very uncomfortable 'one enemy – too many friends' situation. The differing mandates of the coalitions operating in the same theatre might result in duplicate capabilities for slightly different ends. Force commanders might tie A&S assets to specific task forces rather than letting them operate as theatre assets. A&S operations would consequently become fragmented and would not produce the optimal effect that could be achieved by using a synchronised 'system of systems' approach.

It is quite clear that in a scenario where forces (both A&S and maritime) operate as a 'community of shared interest', the Centralised Control – Decentralised Execution Model is not applicable and assets are significantly constrained without a truly 'unified' command. Although within the existing limited CP air community, progress has been made to provide a single coordinating function to improve both mission effectiveness and air safety. It is recognised that the doctrinal C2 concept should be more dynamic in order to cope with disjointed employment of A&S assets.

Recommendation
A&S C2 structure should be flexible and adaptable in order to integrate with other C2 structures and enable the orchestrated employment of A&S assets in the multinational and multi-coalition setting of CP operations.

4.6 Information Sharing

Rationale

Nations and coalitions cannot merge their efforts and intents in a 'community of shared interest' without being a 'community of shared information' first. Information sharing is important for multinational air and maritime forces to operate as a unified, integrated enterprise. Nations and coalitions should develop a 'responsibility to provide' mind-set in which unlocking information would guarantee optimisation of ISR capabilities, synergistic employment of forces and effective tasking of A&S assets.

Also, one of the most direct effects of A&S asset employment in CP is the generating and updating of the Recognized Maritime Picture (RMP). If filtered and declassified, information contained in this picture can be used to provide near real time threat warnings to vessels at sea.

Recommendation
Nations/Coalitions should improve information sharing for the optimisation of A&S assets employment. The classified RMP should be filtered through an unclassified process so as to be used as the basis for a timely alert system for seafarers.

4.7 Policy and Doctrine

Rationale

In recent years, A&S support to Maritime Operations has not been the 'hottest' topic in NATO. As a result, NATO doctrine lacks the necessary operational and tactical guidance for the employment of A&S assets (specifically non-traditional ISR) in the maritime environment, especially in Maritime Security Operations (MSO) scenarios like CP.

Moreover, NATO doctrine is based on the assumption that all entities participating in the mission, will be familiar with, and comply with the guidance offered. The growing complexity of multiple coalitions and nations operating without unified command within the same battlespace but towards similar ends opens the view on new 'waters not yet charted' in current doctrine.

Recommendation
Allied publications, namely AJP 3.3 and AJP 3.3.3, should be refreshed and expanded to cover the employment of A&S assets in the Maritime Domain.

4.8 Air-Maritime Integration

According to NATO doctrine, a substantial A&S contribution in CP would clearly require the presence of an Air Component Commander (ACC) who would support the Maritime Component Commander (MCC). Given the military action mainly occurs at sea and the potentially extensive employment of air assets, strong ACC-MCC liaison relationships should be established.

The complex multinational environment would also require additional levels of liaison in order to guarantee coordination of forces belonging to different nations/coalitions.

Integrated naval and air communication systems should also be implemented to enable 'synapsis' among forces and, at the same time, produce the necessary operational picture for commanders of different nations/coalitions.

These factors, combined with unity of effort and the synergistic employment of assets, would at last elevate operational and tactical relationships between Air and Maritime Forces from the level of coordination to that of integration.

Recommendation
Proper liaison relationships between NATO ACCs and MCCs and also among nations/coalition forces and their integrated naval and air communication systems, should be coordinated to improve Air-Maritime integration.

4.9 NATO Space Capability

Rationale

The primary challenge with using space assets in NATO is the lack of an agency with the authority to bring them into the force mixture. This could be addressed through the implementation of the doctrinal concept of a Space Coordinating Authority, described in AJP 3-3(A) as "the single authority within a joint force to coordinate joint space operations and integrate space capabilities".

Releasability poses a further problem. A space-based system notionally includes three main parts: a ground segment to conduct C2 of the satellite, the satellite itself, and the end-user. The end-user is the consumer of the output. To ensure timely products to the end-user, another intervening level of ground support may be required. A particularly relevant example is the European Union Satellite Centre (EUSC), which has been providing CP applications of space-based ISR to the EU for Operation ATALANTA.

There are numerous imagery satellites in orbit. The EUSC has access to over 30 of them through contracts with either national or commercial entities. The EUSC principally supports Operation ATALANTA with space based imagery exploited to monitor known locations.

An organisation similar to the EUSC is not available in NATO. One way to approach this issue could be through the development of an Alliance capability similar to the EUSC. While desirable, this would require time and funds to build the structure and the necessary relationships with on-orbit satellite providers to deliver analysed information to users. However, the EUSC is available for third party taskings from NATO. These taskings would require approval and may incur a cost. However, given the fact that 21 of the 28 NATO nations are contributors to the EUSC via their membership in the EU, it stands to reason that the EUSC at least warrants consideration as a possible means to make better use of available capabilities in the NATO context.

Alternatively, planners could consider the United States Air Force's Eagle Vision system which is capable of downlinking data from a range of optical and SAR satellites.

Both of these existing options offer NATO an enhanced space capability and guarantee the conversion of the data collected by the satellites into information for commanders at sea.

Recommendations
- NATO should implement the doctrinal concept of Space Coordinating Authority.
- NATO should evaluate the possibility of establishing a link to the EUSC.
- NATO should explore developing an Alliance Satellite Centre.
- NATO should request a national capability such as the US 'Eagle Vision'.

4.10 AIS

Rationale

One of the assumptions of the experiment is the availability of a full AIS satellite constellation, which provides the snapshot of AIS equipped surface traffic. In reality, the AIS picture provided by satellites can also be refreshed by those air breathing assets equipped with AIS interrogation equipment (HALE, AWACS, and MPA).

The AIS picture is the first layer of awareness and it is essential for the building of the RMP. Without this layer, all non-AIS fitted assets involved in the system would have to deal with target de-confliction, which would probably decrease the detection effectiveness of the whole system. Clearly, as a prerequisite for MSA, it is imperative that all merchant traffic 'squawk' AIS. However, AIS receivers are available on the market and pirates could acquire this equipment to increase their own situational awareness, locate vessels of interest and operate more efficiently.

Recommendation

Coalitions should evaluate the possibility of acquiring a future Global AIS-SAT service. It should also be considered part of the NATO Defence Planning Process (NDPP).

4.11 Active Options to Improve Space-Based Effectiveness

Rationale

Given the nature of the threat, it is easier to track and monitor the pirate targets, i.e. commercial shipping, instead of pirates themselves. Vessels desiring protection could be turned into pirate 'sensors'. At the very least, they should be persuaded to cooperate by adopting hardware and software applications to aid monitoring.

One way to accomplish this is through the use of the Iridium satellite constellation. Iridium is a commercial satellite communications provider that is unlike the majority of satellite communications providers. Instead of using large satellites at geosynchronous orbit for persistence, Iridium employs Low Earth Orbit (LEO) satellites. These satellites communicate between each other to provide the user seamless coverage. Iridium publicises a service called Short Burst Data. With a maximum latency of less than 1 minute, users can send short messages via the Iridium constellation. There are a variety of creative ways an application such as this could be used to communicate vessel status or track vessel course. It would also be possible to manually activate an application such as this for alarm situations. Transceivers' prices for this type of application are between 500 and 1000 €.

Another possible active measure which deserves further exploration is the placement of corner reflectors on vessels of interest. Right now, radar satellites rely on the coincidence that ship structures tend to reflect energy effectively. However, it may be possible to add specific types of corner reflectors to either increase the radar return, and therefore their detectability, or even create specific types of reflectors for different classes of vessels aiding classification and identification.

Recommendation

Shipping Companies should be encouraged to evaluate active ISR options which take advantage of the ability for cooperative monitoring and surveillance.

4.12 AWACS

Rationale

Extended endurance through its AAR capability and the airborne maritime radar system makes the E-3 a very effective surveillance asset in the CP scenario.

It also appears that E-3 Link and communication suites improve the degree of integration and interoperability with other assets. This level will be increased in the future thanks to new capabilities currently under development, such as the possibility to control multiple TUAVs from the air.

Moreover, the E-3's ability to perform C2 and Battlespace Management functions are unmatched in the wide array of employable air assets.

For these reasons, the E-3 would be 'the right tool for the job' in CP operations. The only capability missing is 'penetration', which could be provided by powerful EO/IR and SAR systems. With this additional equipment the E-3 would provide full operability and effectiveness not only for detection and tracking but also for identification, completing the full spectrum of ISR tasks in the CP scenario.

Recommendation
NATO should evaluate the possibility of equipping E-3 aircraft with EO/IR and SAR sensors.

4.13 HALE UAS

Rationale

As discovered in experiment OS2, HALE UAS appears extremely effective and would greatly contribute to suspect pirate detection and identification in the course of their patrols of scheduled routes. Depending on priority, these assets could stop their patrol and provide persistent tracking of suspect pirates of high relevance, improving the overall tracking effectiveness of the force mix.

To date, there is no maritime operational scenario as challenging as CP off the HoA. Hence, CP appears to be the perfect setting to test almost all capabilities provided by HALE UAS.

Recommendation
Deploy HALE UAS (namely BAMS) in the CP region for future trial in real operational environment.

4.14 TUAVs

Rationale

TUAVs can be launched and recovered by many ships, even if they have no flight deck. They can also be operated by different control stations (even air-based, such as AWACS or future MPA) for tactical purposes. Currently, this versatility is limited by the philosophy of keeping this type of UAS tied to warships.

In the OS2 asset architecture, launching platforms were pre-positioned in order to guarantee the best employment of TUAVs in the overall ISR endeavour. These launching platforms do not need to be tied to warships. For example, they could be replaced by contracted vessels (with limited military crew on board), able to operate multiple TUAVs.

Recommendation
Evaluate the possibility of using contracted vessels as platforms operating multiple TUAVs.

4.15 Experimentation Campaign

Rationale

Simulations are generally iterative in their development. One develops a model, simulates it, learns from the simulation, revises the model, and continues the iterations until an adequate level of understanding is developed.

As an example, one of the technical findings of experiment OS2 is that the simulation is unable to 'learn' behaviours from previous runs; therefore assets tend to be concentrated in the GoA and BAM due to zonal priority constants being set higher in close proximity to commercial sea traffic (see Figure 3.2, page 23). Assets continue to search and probe these areas due to a high priority resulting from high detection levels. Also, they don't adapt to changes in dynamic disposition of suspect pirates.

In this case, the best solution to revise the model would be the application of a 'human in the loop' and the implementation of a revisited CONOPS for A&S assets. This new non-standalone experiment could also be executed using A&S assets employed ashore and surface assets such as warships, organic helicopters and ground stations.

The following step could be an 'operational' experimentation, which would involve integration of experiment events into near-real (exercise scenario) or real operational environments (CP operations).

As the model is refined providing increasing granularity and tighter bounds, the escalating reiteration process could finally provide a high level of understanding of the model itself. This could lead to the development of a draft CONOPS mature enough for integration into NATO doctrine.

Recommendation
NATO should evaluate the possibility of initiating an integrated experimentation campaign specifically tailored to CP operations.

4.16 A&S ISR Applications in the Maritime Domain

Rationale

In terms of 'enemy' characteristics (especially detectability), many illegal activities at sea are similar to piracy. As a matter of fact, military forces combating piracy, migrant smuggling, human trafficking, drugs and weapons trade at sea all share a common operational requirement: ISR coverage.

Using the OS2 experiment as a case study for A&S ISR support in the maritime environment, the 'system of systems' approach envisioned in the experiment process could be used as a template for the employment of A&S assets in MSO other than CP.

As a clear and contemporary example, a mix of forces similar to the one identified for CP in OS2 could be refreshed and applied in migration control in the Mediterranean Sea, which is expected to be an even more challenging task in the years to come due to recent socio-political developments in Libya, Tunisia and Egypt.

Recommendation
Lessons learned from the experimentation campaign on A&S support to CP could be extrapolated in ways that apply A&S support to other MSO.

ANNEX A

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ANNEX B

Acronyms and Abbreviations

ACC	Air Component Commander
AIS	Automatic Identification System
AIS-SAT	Automatic Identification System Satellites
AO	Area of Operations
AOR	Area of Responsibility
ATO	Air Tasking Order
AWACS	Airborne Warning and Control System
BAM	Bab Al Mendeb
BAMS	Broad Area Maritime Surveillance
BLOS	Beyond Line Of Sight
BLUEFOR	Blue Forces (Friendly)
BM	Battlespace Management
BMP	Best Management Practices
C2	Command and Control
CAVOK	Ceiling And Visibility OKay
CGA	Cooperative Guidelines Agreement
CMF	Combined Maritime Force
CONEMP	Concept of Employment
CONOPS	Concept of Operations
COP	Common Operating Picture
CP	Counter Piracy
CSDP	Common Security and Defence Policy
CTF	Combined Task Force
EO	Electro-Optical
EO/IR	Electro-Optical/Infra-Red
ESM	Electronic Support Measures
ETOS	Effective Time On Station
EU	European Union
EUNAVFOR	European Union Naval Force
EUSC	European Union Satellite Centre
FMV	Full Motion Video
GoA	Gulf of Aden
GSSAC	German Space Situational Awareness Centre
HALE	High-Altitude Long-Endurance
HITL	Human-In-The-Loop
HoA	Horn of Africa
HRA	High Risk Area
IO	Indian Ocean
IR	Infra-Red
IRTC	International Recognized Transit Corridor

ISAF	International Security Assistance Force
ISR	Intelligence, Surveillance and Reconnaissance
I&W	Indicators and Warnings
LEO	Low Earth Orbit
LOS	Line Of Sight
MCC	Maritime Component Commander
MDA	Maritime Domain Awareness
MEDEVAC	Medical Evacuation
MIO	Maritime Interdiction Operations
MMA	Multi-Mission Aircraft
MOE	Measure Of Effectiveness
MOP	Measure Of Performance
MPoL	Maritime Pattern of Life
MPA	Maritime Patrol Aircraft
MSA	Maritime Situational Awareness
MSO	Maritime Security Operations
NAC	North Atlantic Council
NAEW	NATO Airborne Early Warning
NAEW&C	NATO Airborne Early Warning & Control
NAVCENT	Naval Forces Central Command (US)
NDPP	NATO Defence Planning Process
NM	Nautical Mile
NPM	Not Protectively Marked
OA	Operational Analysis
OOS	Operation OCEAN SHIELD
OS1	Experiment Ocean Shield 1
OS2	Experiment Ocean Shield 2
PAG	Pirate Action Group
PoL	Pattern of Life
PPoL	Pirate Pattern of Life
RAAF	Royal Australian Air Force
RMP	Recognized Maritime Picture
RPG	Rocket Propelled Grenade
RSP	Recognized Surface Picture
RW	Rotary Wing
SA	Situational Awareness
SAR	Synthetic Aperture RADAR
SME	Subject Matter Expert
SS	Sea State
TCS	Tactical Control System

TDL Tactical Data Link

TFG Transitional Federal Government

TUAS Tactical Unmanned Aerial System

TUAV Tactical Unmanned Aerial Vehicle

UAS Unmanned Aerial System

UAV Unmanned Aerial Vehicle

UN United Nations

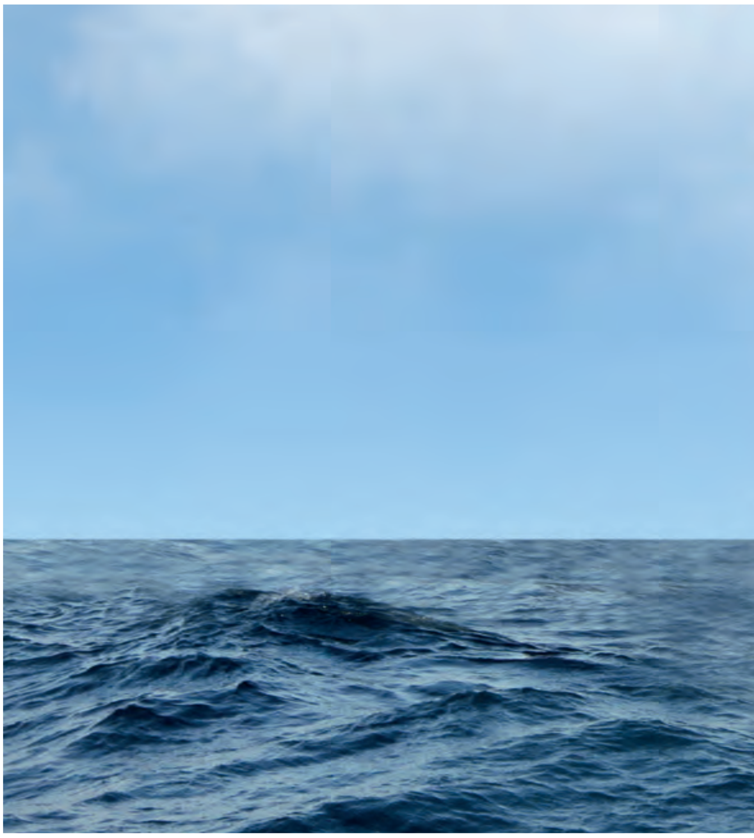
UNSC United Nations Security Council

USJFCOM United States Joint Force Command

VDS Vessel Detection System

VTUAV Vertical take-off and landing Tactical Unmanned Aerial Vehicle

WFP World Food Programme



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