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Capacity building as an answer to piracy in the Horn of Africa

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CAPACITY BUILDING AS AN ANSWER TO PIRACY IN THE HORN OF AFRICA

by

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December 2010

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13. ABSTRACT

The Horn of Africa has become an epicenter of interest for the global community due to the drastic increase in piracy. Indicative of the Gulf of Aden's strategic importance is the fact that more than 30,000 ships per year and 3 million barrels of oil per day transit the Suez Canal. Indicative of the severity of the problem of piracy is the fact that more than 30 countries are committing naval forces as part of a solution to the problem. The international community seeks to secure the area and protect the global economy.

This thesis attempts to provide an innovative sustainable capacity building conceptual model to tackle piracy through the employment of cutting edge technological assets, i.e tethered aerostat radar sensors, UAVs and picosatellites. The economic and technical feasibility of the proposed conceptual model is tackled respectively by illustrating a scenario and providing an economic cost benefit approach regarding the cost of the proposed infrastructure. The conceptual model consists of a complex set of various components that, together, build an integrated architectural set constituting an innovative, alternative capacity-building model aiming to secure maritime traffic corridors, and at the same reducing the economic cost significantly and the number of deployed naval assets.

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CAPACITY BUILDING AS AN ANSWER TO PIRACY IN THE HORN OF AFRICA

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LIST OF ACRONYMS AND ABBREVIATIONS

AIS	Automated Identification System
C2	Command and Control
ESA	European Space Agency
EU	European Union
HNA	Hellenic Naval Academy
HVU	High Value Unit
HoA	Horn of Africa:
GAO	Government Accountability Office
ISR	Intelligence Surveillance Reconnaissance
JLENS	Joint Elevated Netted Sensor System
LCC	Life Cycle Cost
MIO	Maritime Interdiction Operations
NMIOTC	NATO Maritime Interdiction Operational Training Center
PfP	Partnership for Peace
RAID	Rapid Aerostat Initial Deployment
TARS	Tethered Aerostat Radar System
TFG	Transitional Federal Government
UAV	Unmanned Aerial Vehicle
WMD	Weapons of Mass Destruction
WFP	World Food Program

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I. INTRODUCTION

The Horn of Africa is of strategic importance considering its geographical features, mainly its proximity to the Suez Canal. During the last two decades, this area has become the epicenter of interest for the global community due to the drastic increase in piracy. Indicative of the Gulf of Aden's strategic importance is the fact that more than 30,000 ships per year and 3 million barrels of oil per day transit the Suez Canal.

The challenge of piracy is recognized globally; the special conditions of this area create a unique set of considerations and circumstances for policy makers. Indicative of the severity of the problem is the number of think tanks and regional experts that have focused on this issue, as well as the fact that more than thirty countries are committing naval forces as part of a solution to the piracy problem. However, a solution that requires the economic support of a large number of naval units patrolling has a severe economic impact. The current global economic recession makes the situation even worse. Although this deployment of naval forces provides our navies a solid objective, no government expects or wants its naval forces to become part of a permanent anti-piracy patrol in the Gulf of Aden similar to the US forces stationed in Korea.

A. RESEARCH QUESTION

The international community in contemporary times is facing serious challenges in many domains. Issues like terrorism and piracy have entered our daily lives. An imperative need is generated to tackle efficiently all these challenges. From the rocky mountains of Iraq and Afghanistan to the sea commons in the Horn of Africa, the only tool historically proven capable of addressing these challenges is **Capacity Building.**

The major research question in this thesis is the following:

Which capacity-building strategy in the Horn of Africa will most likely produce a solution to the piracy problem?

A major consideration in deciding which capacity-building course of action to pursue lies on how the political situation ashore will evolve.

This thesis attempts to provide innovative solutions to tackle piracy. The majority of regional experts agree that piracy can only be effectively addressed if the coastal states assume responsibilities and exercise effective control over their constituents. Considering the complexities of the region, this is an optimistic scenario. In the case where political challenges on shore result in a stalemate, the international community should take the necessary steps towards capacity building to secure the area and protect the global economy independently of the anomalies happening ashore.

B. LITERATURE REVIEW

There is a consensus in the literature that the roots of piracy are located ashore in political and regional instability. It is clear that piracy only occurs under conditions of weak control over littoral waters and weak institutions that are unable to secure the maritime domain. In the long run, such weaknesses cause destabilization in the wider area, and piracy occurs.[1] Hansen's study on piracy in the Gulf of Aden highlights the role of individuals and local institutions connecting these broader conditioning factors to the particular pattern of piracy in the region.[2] There is also broad agreement that weak economies, which make piracy an attractive occupation to young unemployed men, also contribute significantly to the rise of piracy.[3]

Despite the consensus on the origins of piracy, local and international perspectives on the phenomenon of piracy vary quite significantly. Somalis claim that, in many cases, they are protecting their waters from foreign trawlers. Also, there have been accusations that, due to the lack of coast guard capabilities, attempts were made to illegally dump toxic waste in Somali territorial waters.[4] Furthermore, there are international reports verifying the severe economic damage the Somali economy has

[1] Adam Young, *Contemporary Maritime Piracy in Southeast Asia: History, Causes and Remedies* (Singapore: Institute of Southeast Asian Studies, 2007), 16–18.

[2] Stig J. Hansen, *Piracy in the Greater Gulf of Aden: Myths, Misconception and Remedies* (Oslo, Norway: Norwegian Institute for Urban and Regional Research, 2008), 23.

[3] Ibid., 7.

[4] Robert I. Rotberg, "Combating Maritime Piracy," *World Ppeace Foundation policy brief,* January 26, 2010. http://www.worldpeacefoundation.org/WPF_Piracy_PolicyBrief_11.pdf (accessed April 27, 2010), 4–5.

suffered from foreigners, leading some Somalis to see pirate attacks on large ships outside Somali fishing areas as a justifiable redistribution of income.[5] Locals often do not refer to pirates as pirates, but rather as marines, who they believe to be committed to protecting Somali territorial waters as a consequence of the state failure in 1991.[6]

While it is widely accepted that the lack of central governance has led to the rise of piracy and that the exceedingly weak but internationally recognized government in Mogadishu is incapable of implementing an effective anti–piracy policy, there is debate about whether Islamist groups, which are much stronger than the Transitional Federal Government (TFG), and clan elders, who often continue to exercise significant authority at the local level, could do so. [7] Some analysts note that both sets of actors have expressed strong opposition to piracy and have proven that at least in the short term and under some conditions, they can in fact effectively address piracy. Others argue that Al Qaida-affiliated Islamist groups act as business partners with the pirates and thus cannot be part of the solution, and that clan elders are only able to exercise authority over a very limited space and very specific circumstances. Therefore, the international community is facing the serious dilemma of whether to support extreme Islamists in power in order to counter piracy, when no one can guarantee that there is no linkage between such extremists and terrorist groups.[8]

Some authors argue that an obstacle to effective counter-piracy in our era is that the piracy operations are self-supporting, due to the fact that pirates are very well organized and use modern technology, and that paying the relatively low ransoms demanded is cost-effective for ship owners. This practice among shipping companies allows and even encourages pirates to continue their illegal activities.[9]

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[5] Lauren Bloch, Christopher Blancard and Ronald O'Rourke, *Piracy off the Horn of Africa*, CRS Report for Congress, R40528 (Washington, D.C., 2009), 10.

[6] Mohamed Adow, "Al Jazzera." Demand Al Jazzera. June 17, 2009. http://english.aljazeera.net/news/africa/2009/06/2009614125245860630.html (accessed April 27, 2010).

[7] Melissa Simpson, An Islamic Solution to State Failure in Somalia? *Geopolitics of the Middle East* 2, no. 1 (January–March, 2009), 31–35.

[8] Ted Dagne, *Somalia : Current Conditions and Prospects for a lasting Peace,* CRS Report for Congress, (Washington D.C., October 2010), 13.

[9] Ploch, Piracy off the Horn of Africa, 12–13.

Piracy is now considered a universal crime, and is prosecuted by a large number of countries.[10] However, there is a wider consensus that piracy's roots are located ashore and, usually, it is a consequence of political and regional instability. In our age, piracy is occurring in two areas of major strategic interest, the Gulf of Aden and the Malacca Strait in South East Asia (where the cooperation of regional governments has yielded tangible results). It becomes clear that piracy signals weak control over littoral waters in the region and weak local institutions that are unable to secure their seas and consequently generates destabilization to the involved states. [11]

This literature review stresses that the problem of piracy in the Horn of Africa and how this issue can be effectively addressed depends on how the international community can find innovative ways to intervene in cooperation with local institutions and implement modern technologies.[12] Consequently, it is important to develop a capacity—building strategy in accordance with the political developments ashore. In addition, there are allegations that pirates are affiliated with terrorist groups, so there is a great incentive for the international community to intervene.[13]

The sea commons in the Gulf of Aden have strategic importance, due to the Gulf's proximity to the Suez Canal and the dependence of the international community on natural and manufactured resources that inevitably have to transit this maritime passageway. Over the past several years, there has been an increase in the number of non state-actors that have challenged the safety of these maritime corridors and constitute a threat to international shipping and, consequently, to the global economy. [14] The

[10] William R. Slomanson, Fundamental Perspectives on International Law California (Belmont, CA: Wadworth Thompson Learning, 2007), 245.

[11] Young, *Contemporary Maritime Piracy in Southeast Asia: History, Causes and Remedies*, 15–18.

[12] Jeff Kline, Maritime Security in Securing Freedom in the Global Commons ed. by Scott Jasper, (Stanford, CA: Stanford University Press, 2010), 81–82.

[13] Simpson, *An Islamic Solution to State Failure in Somalia*? 45.

[14] Kline, *Maritime Security,* 68–70.

international community must tackle these challenges and threats coming from non-state actors. Otherwise, these commons will be used by non-state actors to fulfill goals that, in their vast majority violate international law. [15]

The best way to address this threat is by considering the complexities in the area on all levels, from societal fragmentation in clans and sub-clans to specific geographic features of the region. Furthermore, in principle, there are some basic considerations that must govern this policy. These considerations can be summed up as the following: The policy to counter all these threats must be based on local, regional, and international collaboration; otherwise, all efforts to deal with this issue will ultimately fail.[16]

However, in order to successfully coordinate this effort on the long coastline of Somalia, special care and attention should be given to the unique conditions of this area. Specifically, this must be a long-term policy aiming to overcome great difficulties such as high governmental corruption and the fact that many Somalis consider piracy a reliable professional choice.[17] Also, many Somali pirates consider themselves protectors of their waters against foreign trawlers that illegally fish.[18]

In order to achieve an effective maritime control of the dangerous areas, modern technologies under innovative concepts should be followed. Specifically, tethered aerostats, and satellite assets can be used to monitor large maritime areas without the necessity of disposing directly naval forces. Due to the limited number of available naval units, this capacity development strategy could reduce the economic cost of current naval operations.[19]

The current literature recognizes that piracy originates from regional instability ashore and emphasizes building strong local institutions. However, the building of strong

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[15] I. Kline, *Maritime Security,* 68–70.

[16] Ibid., 82.

[17] Hansen, *Piracy in the Greater Gulf of Aden, Myths, Misconception and Remedies*, 9.

[18] Ibid.

[19] Inside the Navy, *Navy Eyes Aerostats for Affordable, long duration, Surveillance* 19, no. 49, December 2006, http://www.tcomlp.com/resources/TCOM%20Inside%20the%20Navy%20Reprint%2012-06.pdf www.defence.com (accessed on 29 September 2010).

institutions is a long-term strategy that requires a lot of support and efforts. This thesis will introduce concepts such as using the capabilities of satellite assets or other man-made assets, like aerostats, in order to establish a recognized maritime picture along the dangerous coastal areas and support safe maritime corridors for the merchants transiting the Gulf of Aden in the short-term. These latter concepts can be developed and allow major international actors like the United States and the European Union to support the tactics discussed above.

C. THESIS OUTLINE

The structure of this thesis will include six chapters, composed of an introduction, development, analysis and conclusions as described below. In the introductory Chapter, this thesis will focus on describing the political problem of Somalia and the complexities that create conditions for piracy to grow and why the international community should follow a different approach in fighting piracy. This thesis will argue that governments should help tackle the problem by implementing innovative concepts with the aid of new technologies to reinforce secure maritime corridors in the Gulf of Aden.

Chapter II discusses about the causal mechanisms of piracy in the HoA and Southeast Asia. Furthermore, it introduces the concept of a capacity-building model, which focuses on addressing the issue from a domestic and an international aspect as well, and then introduces the need for innovative capacity building methods of tackling this issue.

Chapter III presents cutting-edge technologies (UAVs, Tethered Aerostats with embedded Radar sensors, satellite assets) that are applicable to maritime domain awareness and MIO operations.

In Chapter IV, this thesis tests the feasibility and effectiveness of building the infrastructure models described in Chapters II and III—concerning tethered aerostats with embedded radar sensors—by illustrating a maritime scenario in which two merchant ships considered as high-value units (HVUs) transit through the Horn of Africa. Their main objective is to arrive safely to their destination, successfully avoiding piracy attacks.

In Chapter V, a cost-benefit analysis of an air monitoring system consisting of tethered aerostats with embedded radar sensors is presented, in comparison to the current economic cost of deploying a large number of naval assets.

Finally, the last chapter restates conclusions on how and why capacity building of a cutting edge infrastructure in the Horn of Africa will efficiently reduce piracy incidents.

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II. REGIONAL CAPACITY BUILDING

Piracy is an historical phenomenon that dates back to the thirteenth century B.C, when men initiated commerce transactions. However, the causal mechanism of piracy has shifted throughout the years. In order to understand the causes of piracy in contemporary years it would be useful to present the causal mechanisms of piracy in the HoA and Southeast Asia, two strategic areas considered as chokepoints that share a number of similarities.

A. CAUSAL MECHANISM OF PIRACY IN THE HORN OF AFRICA

The literature on this issue concludes that the causal mechanism of piracy in the Horn of Africa includes the following factors: "intrastate conflicts, geography, cultural shifts, ship owner policy, and weak political and security enforcement institutions."[20] For the past two decades, Somalia has been suffering from a civil war between clans, ending up being a failed state. Likewise, due to domestic issues, Yemen is facing the danger of becoming a failed state. Both of these countries are involuntary hosts to pirate groups because internal conflicts provide pirates the supportive environment to direct and conduct operations.[21]

Geography plays an important role. Somalia's coastline is estimated to be around 2000 miles long. Since no coastguard or navy patrols these waters, pirates are able to conduct their operations from a number of different bases with impunity. Historically, the rise of piracy has been supported by the proximity of the Gulf of Aden to the Suez Canal. Yemen's geography is also attractive to pirates due to its long coastline and proximity to high-traffic maritime corridors.[22]

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[20] Stephen L Riggs, *Piracy in the Horn of Africa: A Comparative Study with Southeast Asia*, Thesis, Monterey, CA: Naval Postgraduate School, December 2009. http://edocs.nps.edu/npspubs/scholarly/theses/2009/Dec/09Dec_Riggs.pdf, 8.

[21] Hansen, *Piracy in the Greater Gulf of Aden, Myths, Misconception and Remedies*, 49–51.

[22] Ibid., 50.

Piracy is tacitly supported by a cultural shift on the part of the local populations towards a more lenient sympathetic judgment of the pirates. One of the main characteristics of the area is poverty, and piracy provides money to the area. Many young Somali males view piracy as an optional professional choice.[23]

Finally, two important contributors to the rise in piracy in the area are the lack of a strong judicial/legal system and security enforcement mechanisms. The failed-state status of Somalia limits its ability to put on trial any of the alleged pirates. Furthermore, the European Union member states are unwilling to sign any anti-piracy agreement with Yemen, due to the fact that Yemeni legislation opposes European Union laws regarding human rights on the issue of the death penalty. Consequently, the international community followed a different path, signing a memorandum with Kenya and Seychelles allowing these countries to try alleged pirates.[24]

Another aspect of this issue is the fact that piracy involves a number of jurisdictional restrictions that the international community must overcome in order to intervene. In 2008, after a request from the Transnational Federal Government (TFG) in Somalia, the United Nations issued resolution UNSCR 1851 allowing the pursuit of suspected pirate ships inside Somali territorial waters by foreign non-Somali naval units.[25]

B. CAUSAL MECHANISM OF PIRACY IN SOUTHEAST ASIA

Southeast Asia is the other geographical area where, according to statistics, piracy still occurs, and where it is worth attempting to distinguish the regional factors leading to piracy. The literature leans toward the same factors as those in the Horn of Africa, but in an obviously different context.[26]

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[23] Rotberg, *Combating Maritime Piracy*, 4.

[24] Kline, *Maritime Security*, 78.

[25] Ibid.

[26] Martin Murphy, "Contemporary Piracy and Maritime Terrorism: The Threat to International Security," *Adelphi* 47, no. 388 (June 2007), 13.

The Malacca strait geography is as important as the Gulf of Aden, since the Malacca strait is considered one of the most important global strategic shipping routes. Indicative of the strait's importance is that half of world trade goes through this choke point.[27] The Malacca strait is about 600 miles long and is the frontier between the three states of Singapore, Malaysia and Indonesia. Specific features like the strait's width (in some areas it is only 1.5 miles wide), make it conducive to attacks.

Furthermore, the emergence of piracy has been helped by the fact that these countries do not have the necessary technological assets and means to keep an effective watch over the whole length of the strait. Pirates were left free after the Cold War to continue their attacks since there was no competent security authority to establish order in the Strait of Malacca.[28]

In Southeast Asia from ancient times and in recent history since the 18th century, piracy has provided a supplementary income to some villages. In order to avoid poverty, a number of people found in piracy a supplementary income. The poverty in the region was so high that local fishermen were tempted by the sight of large ships transiting at very low speeds due to local draft limitations. [29] In a sense, the pirates follow the same tactic as the pirates in the HoA; they ask for a low ransom, which after negotiation may end up at only a few thousand dollars- a relatively small amount in the global economy that represents an extremely high amount in the local community.[30]

Finally, piracy is helped by the unique geography and proximity of national borders in specific parts of the strait. The littoral states were motivated to view this problem as a domestic and not a regional problem, a view that inevitably led to a conflict of intra-regional interests. This conflict was further escalated due to the fact that these countries, (as former colonies), are extremely sensitive about sovereignty issues.[31]

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27 Sam Bateman, "Regime Building in the Malacca and Singapore Straits: Two Steps Forward, One Step Back," *Journal of the Economics of Peace and Security*, no. 2. (2009), 45.

28 Riggs, *Piracy in the Horn of Africa: A Comparative Study with Southeast Asia*,26.

29 Murphy, *Contemporary Piracy and Maritime Terrorism: The Threat to International Security*, 17.

30 Riggs, *Piracy in the Horn of Africa: A Comparative Study with Southeast Asia*,29.

31 Ibid., 24.

C. CAPACITY BUILDING IN THE HOA

The preceding analysis of the causal factors of piracy in the HoA and in Southeast Asia clearly demonstrates the problematic nature of this issue by stressing its domestic and international dimensions. Consequently, it becomes obvious that only a consistent capacity building policy against piracy will effectively address this issue.

Capacity building can be defined as:

> Planned *development* of (or increase in) *knowledge*, *output rate*, *management*, *skills*, and other *capabilities* of an *organization* through *acquisition*, *incentives*, *technology*, and/or *training*.[32]

The best way to address the piracy threat is by considering the complexities in the area on all levels, from societal fragmentation in clans and sub-clans to specific geographic features of the region. Furthermore, in principle, some basic geo-political considerations must govern this policy, in particular, anti piracy efforts should be based on local, regional, and international collaboration; otherwise, all efforts to deal with this issue will ultimately fail. [33] The international community can offer temporary solutions by deploying naval task forces (i.e., Operation Atlanta / Ocean Shield / Allied Provider) or by providing weak littoral states with logistical support and aid to exercise more effective maritime control over their areas of responsibility. However, both methods mean many countries must incur a significant economic burden.[34]

The issue of piracy can be addressed permanently only when the involved states establish and have strong local institutions, such as police and coastguard forces. The moment such strong local institutions evolve the level of all criminality including piracy will be reduced significantly. Capacity Building is the best path to accomplish a permanent solution. However, this cannot occur over a short period, but only after a coordinated series of efforts from the international community in cooperation with locals.

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[32] Business Dictionary Com, *Capacity Building Definition*, http://www.businessdictionary.com/definition/capacity-building.html, (accessed on 10 August 2010).

[33] Kline, *Maritime Security*, 78–81.

[34] Rotberg, *Combating Maritime Piracy*, 2.

D. CAPACITY-BUILDING MODEL IN THE HOA

The literature on the issue of piracy has analyzed and demonstrated in depth that the origins of piracy are located ashore and mainly lie in the lack of strong local institutions and a central governing authority. However, the impact of piracy is global and its cost is estimated to be in the range of $billion.[35] The political situation in Somalia has been in a stalemate since 1992, after the disastrous 1991 UN intervention. The international community is very hesitant to deploy ground forces. The prospect of losing soldiers' lives would also exact, a severe domestic political cost for the governments of countries that might deploy ground troops to establish and maintain for some period local order through the founding and perpetuation of efficient in-country institutions.

Capacity building against piracy, as has been eluded previously, should have a domestic, regional, and international component. [36] Consequently, a modern antipiracy strategy should entail an "innovative non-kinetic policy." [37] In particular, this thesis proposes the adoption of a model analogous to the model developed for the Maritime Domain Protection in the Straits of Malacca in 2005 by the NPS Meyer Institute.[38] Specifically, consolidating all anti-piracy efforts under one command would significantly boost the efficiency of the disposed naval patrolling forces in the area.[39]Furthermore, this thesis proposes the establishment of a large scale, air-monitoring system supported by naval assets. This air monitoring system would primarily consist of tethered aerostats with embedded radar sensors, suitable for maritime domain surveillance. The command infrastructure would be supported by a minimum number of naval assets tasked to deter pirates and respond when pirate groups are detected. This new architecture would be

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[35] Ploch, *Piracy off the Horn of Africa*, 12–13.

[36] Kline, *Maritime Security*, 78–81.

[37] Peter Chalk, Power Point presentation for "*Maritime Piracy off the Horn of Africa*," Center for Civil Military Relations, September 2010.

[38] Jeff Buschmann et al. *Maritime Domain Protection in the Straits of Malacca*. Monterey, CA: Naval Postgraduate School, 2005, http://www.nps.edu/Academics/Institutes/Meyer/docs/2005/2005_sea7part1.pdf; http://www.nps.edu/Academics/Institutes/Meyer/docs/2005/2005_SEA7Part%202.pdf (accessed August 20, 2010), 1–5.

[39] Chalk, *Maritime Piracy off the Horn of Africa*.

under the direct command of Command Control and Maritime Fusion Center established in a regional country. One challenge of this conceptual model would be if the majority of the naval assets supporting the air monitoring system are provided by regional entities.[40]

However, the international community, through organizations like NATO, should support navies from regional countries through institutions specialized in providing anti-piracy training. One institution providing the discussed training operating in accordance with NATO standards is the NATO Maritime Interdiction Operational Training Center (NMIOTC) in Crete, Greece. [41] Through NMIOTC, NATO offers such required training in the following fields: "MIO plan development ,Surface, subsurface and aerial surveillance , Boarding process , MIO aspects of Special Operations , MOTC courses to the members of Partnership for Peace (PfP) and MD (Mediterranean Dialogue) countries."[42]

The model described above will be analyzed thoroughly in the following chapters. The international aspect of the issue focuses on securing the sea commons in the Gulf of Aden. However, there is a domestic component, in particular despite the bad political situation; there are actions to be taken on a domestic level. [43] A number of actions that could potentially reduce piracy incidents on a domestic level are stated below

The first step should support the local communities economically in order to provide young Somalis opportunities and incentives to reject the prospect of becoming pirates. Somalia is composed of three different political entities, Somaliland, Puntland, and the area under the control of the official Transitional Federal Government (TFG). Although, the TFG has a limited role, since the area under its rule is estimated to be only a few building blocks in Mogadishu, the governing authorities of Puntland and Somaliland on a domestic level have proven to be efficient in building strong local

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[40] Kline, *Maritime Security*, 78–81.

[41] NATO Maritime Interdiction Operation Center (NMIOTC), *Training Areas and ACT Courses*, www.nmiotc.gr, (accessed in October 6, 2010).

[42] Ibid.

[43] Chalk, *Maritime Piracy off the Horn of Africa*.

institutions, i.e., coastguard and police, and their efforts should be supported. [44] Another promising development that requires further support is the Somali Coastguard that was recently founded; however, it is poorly equipped, operating only a dozen of skiffs. [45] A policy strengthening equipment wise and enhancing the "know how" of the local institutions of the political entities in the area would cause a drastic reduction of piracy incidents since it would allow law enforcement mechanisms to put their hands on pirates on their own court. [46]

E. CONCLUSIONS

Piracy is a source of regional instability and promotes as well the continuation of the present, chaotic, maritime security stalemate. The strategic significance of the Gulf of Aden with respect to global commerce is fundamental; consequently, the international community should take all necessary measures to secure, the safe passage of international shipping. Unfortunately, only a limited number of actions are available to touch the shelters of piracy, and ultimately, deter pirates permanently. The only efficient course of action to be followed focuses on securing the sea commons, and, specifically instigating an innovative capacity building, pursuing the integration of innovative technological assets. In particular, the current method of dealing with piracy by deploying naval units apart from being only partly effective is also very expensive for the contributing countries considering that a monthly deployment of a frigate-size ship is $1.3 million. [47] Thus, the high cost piracy of piracy generates a sustainability issue which in the long run would lead the involved countries to pursue alternative innovative methods of tackling piracy, less expensive and would not involve such a high number of naval assets.

[44] Chalk, *Maritime Piracy off the Horn of Africa*.

[45] Ibid.

[46] Ibid.

[47] Ibid.

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III. INNOVATIVE TECHNOLOGIES APPLICABLE TO MARITIME INTERDICTION OPERATIONS (MIOS) AND MARITIME SURVEILLANCE IN THE HORN OF AFRICA

The modern maritime environment presents many challenges to the international community. The issue of piracy is a hot issue in the global security arena, since 70% of the earth's surface is covered from water and the vast majority of humanity is highly dependent on the sea and its goods. It is widely known that piracy is an ancient phenomenon, but many seem to forget that anti-piracy efforts are also very old. Another key factor is the degree of advanced technologies utilized by modern pirates that automatically provide them a strategic advantage over merchant ships. Epigrammatically, the Gulf of Aden is a huge maritime domain where, currently, the international community is attempting to address piracy via the deployment of naval units. Although more than 30 countries have deployed naval forces, in 2009 there was an increase in piracy attacks, reaching 196 attacks.[48] Furthermore, as it was eluded in the previous chapter, a sustainability issue is generated since it is highly questionable if the involved countries would continue contributing naval forces and on the same time producing moderate operational results in regards to the number of piracy incidents. The statistics from the IMB in 2009 are a clear indication that a different policy should be pursued that is more efficient and less expensive.

The main reason this chapter is incorporated into this thesis research is to enhance some sporadic "out of the box" thoughts that policymakers are significantly interested in effectively tackling the issue of piracy should consider. Innovative considerations include the utilization of aerostats, satellites and/or other suitable unmanned aerial vehicles (UAVs) in maritime surveillance and MIOs, using technologically advanced assets in a pioneering and innovative fashion would severely reinforce anti-piracy efforts.

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[48] ICC International Maritime Bureau, *Piracy and Armed Robbery against Ships Annual Report*, United Kingdom, January 1 – December 31, 2009.

A. TETHERED AEROSTAT RADAR SENSORS

1. History and Current Deployments

Aerostat operations date from the American Civil War, and since then they have been heavily utilized operationally in the field. Today, aerostats are deployed in a wide spectrum of operations, covering from operations in Afghanistan to a monitoring system in the southern borders of the United States for drug interdiction. The Tethered Aerostat Radar System (TARS) area of responsibility covers the southern US border from Mexico to the Caribbean.49 The latter monitoring system was established in the 1980s and each aerostat is embedded with a radar sensor. Specifically, the TARS system payload consists of AN/DPS-5 S-band CFAR/MTI and AN/TPS-63 search radars. The operational endurance of aerostats can last up to a month and their footprint is around 200 miles. [50]

Finally, another significant contemporary operational application of aerostats in modern challenges is the JLENS (Joint Elevated Netted Sensor System), which has the capacity to detect long- range missiles and has an embedded, radar sensor payload. The latter system is employed by the US Army.[51]

2. Description of Tethered Aerostats

Tethered aerostats form a category of air systems that can be easily characterized as non- conventional since they do not have fixed rotary wings. The majority of these network balloon systems are employed in surveillance missions with embedded radars, consist of four main parts, "Radar sensor, wind screen, airborne power generator, rigging tether assembly and hull." [52]

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[49] Department of the Air Force, *Tethered Aerostat Radar System*, Air Combat Command Public Affairs Office, (January 2003),http://www.acc.af.mil/library/factsheets/factsheet_print.asp?fsID=2359&page=1 (accessed 29 September 2010).

[50] Ibid.

[51] Christopher Bolkcorn, *Potential Use of Airships and Aerostats*, CRS Report for Congress, (Washington D.C., 2004) , 2.

[52] Ibid.

The majority of hulls are manufactured of polyurethane-coated fabric. The upper part is larger and contains the required helium to remain at the proper altitude. The ballonet lower part is subject to the effect of pressure, and its shape is affected by the various pressure changes related to the aerostat altitude. The windscreen is also under helium pressure and is the compartment facilitating the radar.[53]

Figure 1. Tethered Airborne Radar Systems[54]

The whole structure is supported through suspension and mooring lines that can anchor aerostats at elevation of up to 15,000 feet.[55]

3. Operational Advantages From Using Tethered Aerostats

Currently, there is strong debate over unmanned air assets and how they can be optimally utilized. Inevitably, this discussion involves aerostats and what they can offer to tackle modern challenges mankind is facing. In regards to maritime domain surveillance, this technology can offer a number of serious advantages. Aerostats can assume a variety of roles based on the wide variety of payloads they can carry. In particular, they can function as communication relay assets, but there is also great potential in ISR missions. In maritime missions, especially the main need emerging from

53 Department of the Air Force, *Tethered Aerostat Radar System*.

54 Ibid.

55 Ibid.

modern security issues is to create sea-based assets able to detect and identify threats in a timely manner. [56] The role that seems fit for aerostats is "persistent surveillance"; this thesis proposes a conceptual model which consists of an air monitoring system for high-traffic maritime zones appears as the most suitable.[57]

Another set of advantages is that currently similar systems are already operational and there is a general body of knowledge available concerning the range of capabilities and limitations. [58] An important aspect of employing aerostats in maritime surveillance missions is the fact that their economic costs are low and they have a long period of operational life. [59] Yet another argument supporting their use is their low radar cross section and they are fabricated in a fashion that builds in resistance to various punctures.[60] However, a caveat when utilizing aerostats is that they are affected when strong winds blow. Practically, while meteorological phenomena of strong winds occur in an area, an alternative method of conducting ISR should be at hand and pursued until a technological solution is found to bypass this limitation.[61]

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56 Bolkcorn, *Potential Use of Airships and Aerostats* 2–4.

57 Inside the Navy, *Navy Eyes Aerostats for Affordable, Long-Duration, Surveillance*.

58 Bolkcorn, *Potential Use of Airships and Aerostats*, 4.

59 Ibid.

60 Ibid.

61 Ibid.

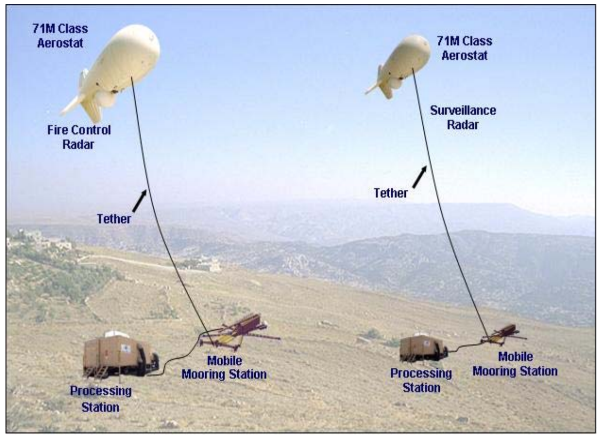

Figure 2. JLENS schematics[62]

However, another interesting application concerning the operational usage of aerostats is based on a concept developed by the U.S. Coastguard in the1980s and 1990s. [63] Specifically, the concept was based on a naval asset that had an embedded aerostat system that was launched when required. These assets were utilized against drug smugglers with success; their main task was to provide surveillance information to the other patrolling units in the area. [64]

62 Defense Industry Daily, *Air JLENS Concept*, http://media.defenseindustrydaily.com/images/AIR_JLENS_Concept_lg.jpg, (accessed on 03 October 2010).

63 United States Coastguard, *Aerostat Program*, http://www.uscg.mil/history/articles/Aerostat.asp, (accessed on 03 Oct. 2010).

64 Ibid.

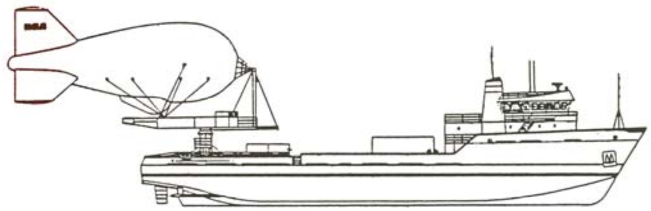

Figure 3. A schematic of a coastguard ship with en embedded aerostat radar system[65]

An innovative approach against piracy would involve the development of modern units capable of carrying aerostats with a large footprint, equipped with advanced radar systems delivering high resolution capable of identifying pirate's mother ships.[66]

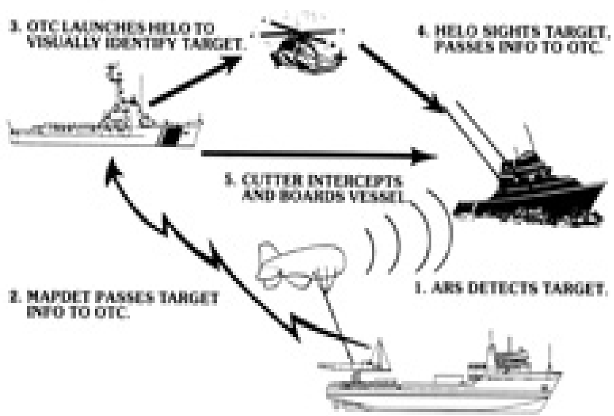

Figure 4. The operational concept when deploying ships with an embedded radar system[67]

Figures 4 and 5 illustrate the concept behind an operational scheme employing embedded aerostats on naval assets. Obviously, one of the advantages of deploying an asset as described above is the fact that it can be considered a sea-based unit capable of

[65] U.S. Coastguard, *Aerostat Program*.

[66] Ibid.

[67] Ibid.

covering a large area for a long period of time in the heart of the problem, significantly reduces reaction time, when supported accordingly. The operational advantage when deploying ships with an embedded aerostat radar system lies on the rapid detection of potential pirate's mother ships.

Another promising application of maritime surveillance systems based on the utilization of tethered aerostats would be what is currently being developed by the Israeli Armed Forces and has received considerable interest from other countries. In 2009 India procured two (EL/M 2083) Aerostat Radars. [68] However, EL/M 2083 radar mainly function against low fast moving aircraft.[69] On the other hand, a maritime application of a tethered aerostat constellation system could be embedded with a radar system designed to operate in a maritime environment, taking into account that the discussed aerostat system could safely maintain an altitude of 15,000 feet, and carry a payload of up to two tones.[70] In particular, the main challenge in securing a maritime domain through this concept is the acquisition of radar capable of covering an area of such size with high resolution. A trustworthy solution might involve the utilization of 3D, phased-array radar system.

B. INNOVATIVE USAGE OF SATELLITE ASSETS IN MARITIME SURVEILLANCE

1. Introduction

Another innovative approach regarding MIO operations involves the use of space-based technologies, in particular picosatellites, in a non-traditional fashion (See Figures 6 and 7). [71]

[68] Strategic Page, *India buys Israeli Aerostat Radars*. http://www.strategypage.com/htmw/htada/20090123.aspx, accessed on (11 October 2010).

[69] Ibid.

[70] Ibid.

[71] Alex Bordetsky, *Micro and Pico Satellites in Maritime Interdiction Operations*, 15th International Command & Control Research & Technology Symposium, June 2010, 17–19.

Picosatellites are the satellite assets that weight less than 1 kgr. The table below presents, all categories of small satellites in order to render a wider sense of their possibilities.[72]

Small Satellite Categories	**Weight**
Large	> 1000 kgr
Medium	500 - 1000 kgr
Mini	100 – 500 kgr
Micro	10 -100 kgr
Nano	1 – 10 kgr
Pico	0.1 – 1 kgr
Femto	< 100 gr

Table 1. Small Satellite Categories

Figure 5. A Picosatellites in Orbit[73]

[72] Bordetsky, *Micro and Pico Satellites in Maritime Interdiction Operations*, 17–19.

[73] Ibid.

Figure 6. A Close Picosatellite Photograph[74]

The picosatellite models described previously, although perhaps not initially developed to operate against piracy , could be easily used in the wider area of the Horn of Africa (HoA), after the adoption of a number of modifications, in maritime surveillance nissions. However, it is important to stress that. although there is great potential in this field, it has not been fully exploited or given the required attention. [75]

2. Operational Advantage Using Picosatellites

Due to their size, small satellites inherently face a number of operational limitations; consequently, picosatellites are not always applicable to all MIO missions. However, they do have a number of advantages that we can make the best use in order to achieve reliable operational results.[76]

Picosatellites offer users global coverage with only 4–6 satellites. The cost of deploying picosatellites is acceptable, since the rocket launching system has the capability of re-launching over thirty times.[77] Another advantage of using picosatellites is that their ground stations can be all over the world, without restriction, something that is convenient for maritime domain protection missions since they are not geographically

[74] Bordetsky, *Micro and Pico Satellites in Maritime Interdiction Operations*, 17–19.

[75] Georgios Mantzouris, Picosatellites in MIO Tracking WMD Materials, *NMIOTC Journal* l (2010), 15–17.

[76] Mantzouris, *Picosatellites in MIO Tracking WMD Materials*, 15–17.

[77] Ibid.

anchored. In addition to the above, picosatellites can remain in orbit for more than seventy days, a feature allowing persistent maritime surveillance.[78]

3. Operational Features of Various Picosatellites

a. Tubesat – Interorbital Company

Currently, a considerable number of operational picosatellites are capable of participating in MIOs, i.e., Tubesat – Interorbital Company. The operational features of the discussed satellite are listed below:[79]

Property	Description
Weight	0.75 kg
Endurance	Up to 3 months
Orbital Altitude	310 Km
Standalone System	Capable of relaying Space to Earth Video

Table 2. Main features of Tubesat Satellites

b. European Space Agency Satellite Receiver for Global Tracking of Ships

Another innovative concept being developed by the European Space Agency (ESA) in cooperation with the private sector provides a trustworthy alternative to the issue of piracy. The fact that this system operates in the space domain offers potential users a high number of advantages and, most importantly, its operation does not come across any geographical or jurisdictional constraints. [80]

[78] Mantzouris, *Picosatellites in MIO Tracking WMD Materials*, 15–17.

[79] Ibid.

[80] Ibid.

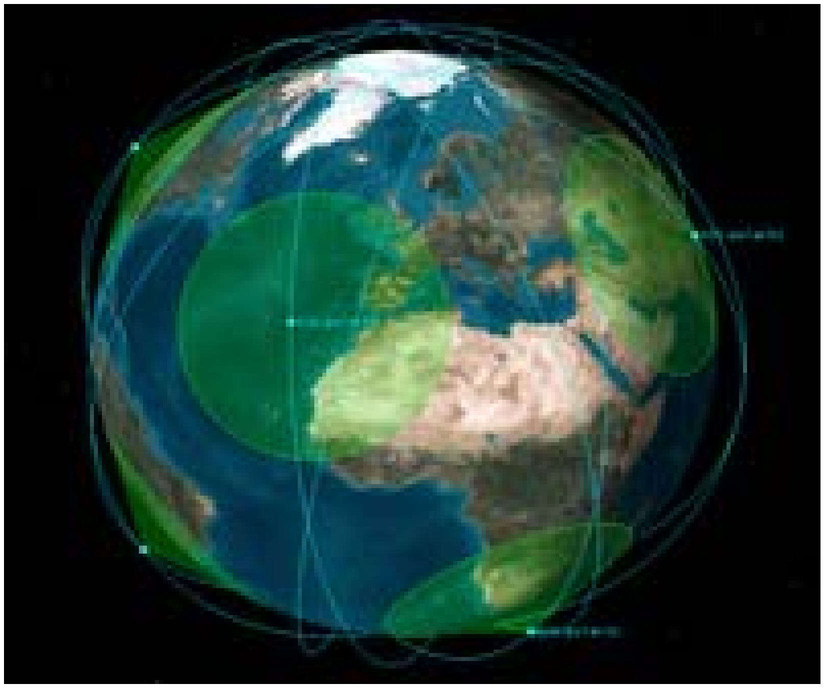

Figure 7. ESA's AIS Signal Coverage[81]

A significant advantage to the use of a constellation of satellites for MIOs where the detection capability is mainly based on signal receiving is the limited number of satellites required to accomplish global coverage, approximately five. [82] Nowadays, all ships which hold a tonnage above 300 tonnes are obliged to be carry an AIS system; consequently, a space monitoring systems that takes advantage of this signal is a great tool in regards to maritime surveillance.

C. UNMANNED AERIAL VEHICLES (UAVS)

1. Introduction

UAVs have become a crucial tool in all kinds of warfare. There is a large number of deployments where UAVs are employed. The history of UAVs dates back to the American Civil War where they were first used as a carrier of explosives to the enemy's

[81] Mantzouris, *Picosatellites in MIO Tracking WMD Materials*, 15–17.

[82] Ibid.

lines. Since then UAVs have been employed in all major conflicts but, due to rapid technological development, the spectrum of operational capabilities has increased tremendously, providing the senior tactical commander a wide spectrum of capabilities starting from real time picture to launching efficient weapons.

The first Gulf War and the war in the Balkans in 1990s clearly demonstrated that a wise operational deployment of unmanned assets like UAVs offers a strategic advantage over any enemy. There is a lot of research effort in manufacturing compact UAVs since, in spite of their size; they can carry cutting edge technological assets. They could be critical assets in MIO operations where the main interest in utilizing UAVs is to monitor large maritime areas and long coastlines that periodically shelter pirates. Finally, the next generation of UAVs will be more efficient, more compact, less expensive and friendlier to their respective operators, capable of participating in complex missions.[83]

According to the 2003 Naval Transformation Roadmap, Information Surveillance Reconnaissance (ISR) capabilities will be greatly enhanced when the next generation of air assets is officially deployed. Specifically, UAVs that are tasked to perform maritime surveillance equipped with various sensors and that are networked will play an important role in the "*reach, coverage and persistence of the naval Information Surveillance Reconnaissance (ISR) system across the full range of the intelligence spectrum.*"[84] Future advanced maritime networks involve a comprehensive set of "air assets, manned and unmanned, and sea-based and land-based assets."[85]

2. Innovative Use of UAVS on Maritime Domain Awareness in the Horn of Africa

There is a vast literature covering the issue of UAVs and currently extensive research is being conducted on potential applications. Apart from widely known applications i.e SCANEAGLE and GLOBAHAWK that presently or in the near future

[83] J. R. Reinhardt, James J. E. Flanagan, *Future Employment of UAVs*, Joint Force Quarterly (1999), 36–37.

[84] Department of the Navy, *Transformation Roadmap, Assured Access & Power Projection from the Sea*, 2003, 71.

[85] Ibid.

after modifications are capable of performing maritime surveillance missions; this thesis proposes the usage of already available UAVs in a pioneering fashion.

The Hellenic Naval Academy (HNA) is developing a mini Helicopter that presents significant potential in the area of maritime domain awareness in the HoA. The mini-helicopter is named Vellerofontis, and was obtained from the commercial sector. The capabilities provided through this mini-helicopter are a comparative advantage over other UAVs including the ability to perform a short take off and to land on a ship deck. [86]

Figure 8. Vellerofontis during a flight carrying a camera streaming video.[87]

Vellerofontis is remotely controlled and carries a video camera that can be also remotely controlled. The main operational characteristics of Vellerofontis are shown in Table 3:[88]

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86 Ioannis Koukos, Maritime Situational Awareness through Unmanned Mini Helicopter, *NMIOTC Journal* 1 (2010), 20–22.

87 Ibid.

88 Ibid.

88 Ibid.

Characteristics	Metrics
Useful load	~ 4kgr
Range	~ 7 nm
Speed	80-100 Km/h
Camera FOV	30◦

Table 3. Vellerofontis operational characteristics

Vellerofontis includes these promising capabilities:[89]

1. Secure Image Transmission.
2. A flight system capable of conducting an autonomous flight with predefined flights.
3. Integration of an IR or Synthetic Aperture Camera as a sensor system that can transmit real time Video.
4. Integration of a light WMD sensor.

In sum, Vellerofontis introduces an innovative way to tackle threats related to the Maritime Domain Awareness at a very low price. The low cost in accord with the small size, makes it possible to utilize Vellerofontis in a number of cases. In boarding operations, Vellerofontis could be deployed in advance to conduct pre-boarding checks and assure the existence of the necessary pre-conditions for the boarding team to be actually deployed. [90] Furthermore, in the near future, Vellerofontis could potentially carry a WMD sensor and relay signals indicating the existence of WMD material back to a central unit for further evaluation.[91] Vellerofontis is currently used for training purposes in NMIOTC, and the lessons learned from various training exercises clearly indicate the large number of potential applications in maritime interdiction operations.[92]

[89] Koukos, Maritime Situational Awareness through Unmanned Mini Helicopter, 20–22.

[90] Ibid.

[91] Ibid.

[92] Ibid.

D. CONCLUSIONS

A great number of innovative applications could be utilized in maritime surveillance missions. However, since not all meet the standards of each mission, the selection of technological assets assigned in each mission should be performed with great caution and consideration; otherwise money may be spent carelessly and at the same time jeopardize maritime security. The technological assets discussed in this chapter present significant potential, and a strong case can be made that the potential utilization of these assets would provide a new momentum to anti-piracy efforts and policies.

Specifically, the utilization of tethered aerostats in a maritime surveillance role constitutes a resourceful approach. Still, there are many issues to be addressed in advance. The most intriguing challenge is the selection of radar incorporating all the desired features. A modern application that should be further investigated is a 3D phased-array radar with AIS equipment embedded providing an effective footprint up to 200 nm.

The next two chapters demonstrate the technical and economic feasibility of an anti-piracy strategy in the Gulf of Aden that utilizes tethered aerostat systems with suitable radar sensors, supported by a minimum number of naval assets, and coordinated from a command and control center stationed in one of the regional countries. Finally, the most important advantage of using aerostat radar systems to fight piracy is their mobility, a property that is crucial since the pirate shelters are not geographically anchored. This is a great advantage since piracy is not a static phenomenon, but constantly relocates.

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IV. MARITIME SCENARIO

A. INTRODUCTION

The Horn of Africa has become an epicenter of interest for the global community due to drastic increases in the levels and boldness of piracy. Since the piracy phenomenon occurs in the high seas it is very difficult to test proposed conceptual models, consequently an initial scenario was developed in order to determine if there is any potential involved in the described capacity model of maritime surveillance. Consequently the scenario described in this chapter was developed. This scenario's hypothesis is the following: The establishment of an aerial monitoring system consisting of aerostats mainly and other unmanned aerial vehicles along the Somalia coast, supported by a minimum number of naval assets and a stronger command and control system, would effectively strengthen anti-piracy efforts.

In order to achieve an effective maritime control of the contested areas, modern technologies under innovative concepts should be followed. As addressed, tethered aerostats can be used to monitor large maritime areas without the necessity of directly disposing naval forces. In particular the concept proposed focuses on the use of aerostats in order to establish consistent, recognized maritime picture along the dangerous coastal areas and support safe maritime corridors for the merchants transiting the Horn of Africa.

B. PURPOSE

The main scope of the scenario presented in this chapter is to demonstrate the feasibility of conceptual models that would tackle the issue of piracy effectively in the sea commons, specifically in the Horn of Africa. The proposed conceptual model consists of a complex set of various components and which together build an integrated architectural set constituting an innovative, alternative approach into securing maritime traffic corridors. Apart from specific assumptions explicitly stated below, the scenario does not take into account the contemporary regional diplomatic and political agenda that develops in the Horn of Africa. The long-term objective of this study is to produce a conceptual model that, under proper modifications, could provide an alternative solution to the issue of piracy and is characterized by three main features:

(a) Cost effectiveness
(b) Advanced Technologically
(c) Participation of regional countries

Historically, in a vast number of issues, capacity building has been more effective whenever locals and regional players are involved. A good example where the collective effort for maritime security succeeded is the Strait of Malacca, where piracy occurred extensively.[93] The challenge of this chapter is to present the feasibility of a large-scale air monitoring system supported by minimum number of naval assets. For this scenario, the Paretto set concept was used to select an optimal solution satisfying all the involved parameters (design variables, functional constraints, criteria constraints) which are defined in each problem individually. [94]

C. CONCEPT OF OPERATIONS (CONOPS)

In order to discover the optimal configuration of advanced technological assets, it is fundamentally important to explicitly state the proposed concept of operations (CONOPS) and avoid misdirecting efforts.

CONOPS: The Operational utilization of cutting-edge technological assets (Tethered Aerostats + suitable radar sensors) in conjunction with a Maritime Command and Control Fusion Center and with the support of a minimal number of naval assets (Naval and Coastguard Units) would provide an alternative solution to address piracy, regardless of the political anomalies happening ashore. Based from the previously

[93] ICC, International Maritime Bureau. *Piracy and Armed Robbery against Ships Annual Report*, (United Kingdom, January 1 – December 31, 2009).

[94] Tomoyuki Hiroyasu, Shinpei Chino, Mitsunori Miki, "Flexibility of Design Variables to Pareto-Optimal Solutions in Multi Objective Optimization Problems," *IEEE Congress on Evolutionary Computation (CEC 2007)*, 4262–4468.

described CONOPS, the discussed infrastructure should be supported by an advanced network mechanism. In particular, the network mechanism should support the following key elements:

1. Sensors

The ultimate objective of a sensor system tasked to monitor a maritime domain is to provide as consistently reliable 24/7 real time picture, as less possible affected by extreme weather conditions. The main features of a sensor system satisfying the criteria for monitoring a maritime domain like the Gulf of Aden are listed below: "*Continuous coverage of all Areas of Responsibilities (AORs), Capability of utilizing alternative Sensors in case of default, interconnectivity, scalability and mobility, advanced network infrastructure, high information quality*." [95]

2. Maritime Command and Control Fusion Center

The infrastructure discussed in this thesis should be also supported through a command and control center stationed in one of the relatively political stable countries of the region, since the compilation of maritime picture is a complex and challenging task. The Maritime Command and Control Fusion center would consist of two main sub-departments:

a. Command and Control Center (C2)

b. Fusion Center

The fusion center gathering all the information would be located in a stable strategic location in the Gulf of Aden, i.e Socotra Island, Somaliland. This C2 center would collect all the information, starting with the tethered aerostats, and notify merchant ships transiting in the area by all available means. Every effective military C2 system is

[95] Jeff Buschmann et al., *Maritime Domain Protection in the Straits of Malacca*, 50–55.

dictated by the following principles: “Command, proximity, support.”[96] An important feature of C2 systems is that command relationships, whether direct or indirect, always remain active. Effective command requires a constant flow and exchange of information without any interference from various factors and third parties.[97] This flow of information includes all the operational and informational data required by operational commanders to conduct successful anti-piracy operations and involves senior tactical commanders and their subordinate commanders.[98] In the case of naval operations, this exchange of information focuses on operational and intelligence information between operational and tactical headquarters.[99]

A fundamental aspect of network hierarchy relates to the fact that the flow of information from one specific command level to senior or subordinate commands reflects the command hierarchy. However, experience has demonstrated that, practically, a typical commander must establish communication and information flow one level up and two levels down in the command hierarchy.[100]

3. Naval Assets

In this thesis, it has been argued that a viable counter-piracy must include a series of coordinated efforts on a local, regional and international level. The conceptual model developed in this thesis attempts to incorporate all respective efforts. In particular, the C2 Center would be established in a bordering country to the area: Yemen (Socotra Island) or Djibouti are potential hosting countries. Furthermore, since our area of focus is the maritime domain naval assets are required. The deployed naval forces can either have an international origin or regional origin. Currently, more than thirty countries contribute

96 RTO Information Systems Technology Panel Task Group. "Chapter 3 - Army Tactical Command, Control and Communications Environment." In *RTO-TR-IST-030 Information Management over Disadvantaged Grids*. Vol. RTO-TR-IST-030, 3-1-3-4. Brussels, Belgium: NATO Research and Technology Organisation, 2007, http://www.rta.nato.int/pubs/rdp.asp?RDP=RTO-TR-IST-030 (accessed August 20, 2010).

97 RTO Information Systems Technology Panel Task Group. " Chapter 3 - Army Tactical Command, Control and Communications Environment.”

98 Ibid.

99 Ibid.

100 Ibid.

naval forces; however, regional countries, Kenya, Yemen, Djibouti and Seychelles should be more engaged in this effort. However, the aim should be reduction of naval deployments to a minimum number where the majority of naval assets originate from regional countries.

D. FUTURE MARITIME NETWORKS

Every maritime challenge should be addressed driven by the quote stated below by Giulio Douhet, an Italian strategist in 1921:

> *Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.*[101]

This thesis aims to transform the international community's maritime security policy, which is heavily based on the deployment of naval units in the area. The policy causes a significant economic burden to all the involved countries. In particular, this work proposes the implementation of innovative concepts and technologies to reduce naval units to the minimum number required to interdict pirate groups that remain undetected—and endanger the safe transit of merchant ships. Consequently, an imperative need is to develop maritime networks competent enough to monitor and deter pirate groups.

Specifically, to successfully counter piracy, it is crucial to improve the recognized maritime picture, providing tactical commanders optimum situational awareness. Necessarily, maritime security depends on maritime surveillance, and there are inherit obstacles to be bypassed when conducting surveillance in an area as large as the Horn of Africa.

Tactical commanders require an information infrastructure that is interconnected and supported by cutting-edge technologies. The architecture of a Command and Control

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[101] Commando Supremo, *Italy at War*, http://comandosupremo.com/douhet.html, accessed on September 2010.

System network is composed of the following subsystems, which are integrated and form nodes: "*navigation components, command and fusion centers, communication links, decision components (i.e computers), sensors*." [102]

One might expect that with the available volume of information, pirates can be easily deterred. However, this is not always the case, since a key factor to successfully conducting anti-piracy operations is to effectively process all the available information. A crucial component of the latter process is to identify all the important data, and after a reliable "*data mining*" process, to utilize them in the decision making process.[103]

The following statement should dictate what the international community and coalition forces should attempt to establish in the future:

> Tactical networks or network centric systems, in which multiple sensors or geographically distributed units of highly mobile decision makers transfer and analyze data while operating on the move in distant areas.[104]

It is quite evident that this approach of building maritime networks is applicable and adaptable to networks whose architecture includes a high number of nodes. Building a network is a relatively common procedure; however, in cases where the objective is to build wide networks, with architectures of numerous nodes, experimentation is required in order to test and evaluate fundamental system properties (i.e., hierarchy, adaptation, etc).[105]

E. NETWORK HIERARCHY

Hierarchy is a fundamental property in networks and defines the network architecture significantly. Consequently, it is important to present the network hierarchy in order to analytically depict the operating mechanism of the proposed conceptual

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102 D. Curtis Schleher, *Electronic Warfare in the Information Age*, Artech House Radar Library, 1999, 5.

103 Konstantinos Tsakonas, "Importance of Future Networks and Capabilities for Maritime Security," *NMIOTC Journal* 1(2010), 23–25.

104 Ibid.

105 D. Alberts. & R. Hayes, *Code of Best Practice: Experimentation*, Information Age Transformation Series (Washington, DC: CCRP Press, 2005), 58–60.

model. Every network has its own characteristics and specifically, the number of layers n and the contents of each layer. Likewise, the quality and quantity of information shared between layers is exclusively designed for any individual network. In particular, there is one common principle always: the scope of each layer is to offer a specific type and amount of information to higher layers.[106]

The behavior of man depends on the relevant context. Likewise, for successful communication between layers a specific set of rules and procedures should be followed; otherwise, there is a strong chance that the communication would fail. [107] The set of these procedures and rules is officially described as a communication protocol.[108] Furthermore, a key aspect of this agreement between layers is the interface used each time the layers communicate. [109]

Many times a need emerges to redesign the network architecture in order to facilitate the augmented needs for data fusion and dissemination. In particular, the network infrastructure supporting ISR efforts against piracy should be able to deal more effectively with the information load between the "*processing the analytic power resident afloat and the capacity ashore and reach-back nodes, as well.*"[110]

F. COMMUNICATION REQUIREMENTS

The communication features of the communication scheme that would be able to support the needs for the discussed conceptual model are the following: "Accommodate mobile nodes, interoperable with existing systems, bi-directional channel, asymmetric bandwidth, Digital, time latency." [111]

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[106] MariosAlexandrou.com, *Network Protocol Hierarchy Definition*, http://www.mariosalexandrou.com/definition/network-protocol-hierarchy.asp, (accessed on August 2010).

[107] MariosAlexandrou.com, *Network Protocol Hierarchy Definition*.

[108] Ibid.

[109] Ibid.

[110] Department of the Navy, "Transformation Roadmap, Assured Access & Power Projection From the Sea," 69.

[111] Meyer Institute, *Maritime Domain Protection in the Straits of Malacca*, 67–69.

A look at the above sensor requirements and to the relevant literature would suggest that networks should be considered as a "set of nodes interconnected through a number of links."[112] In particular, this work refers to a maritime domain protection system that would employ a set of sensors to detect, deter and provide senior commanders the ability to conduct anti-piracy operations. A mesh network structure in conjunction with a hierarchical structure appears to be the best network configuration to adopt.

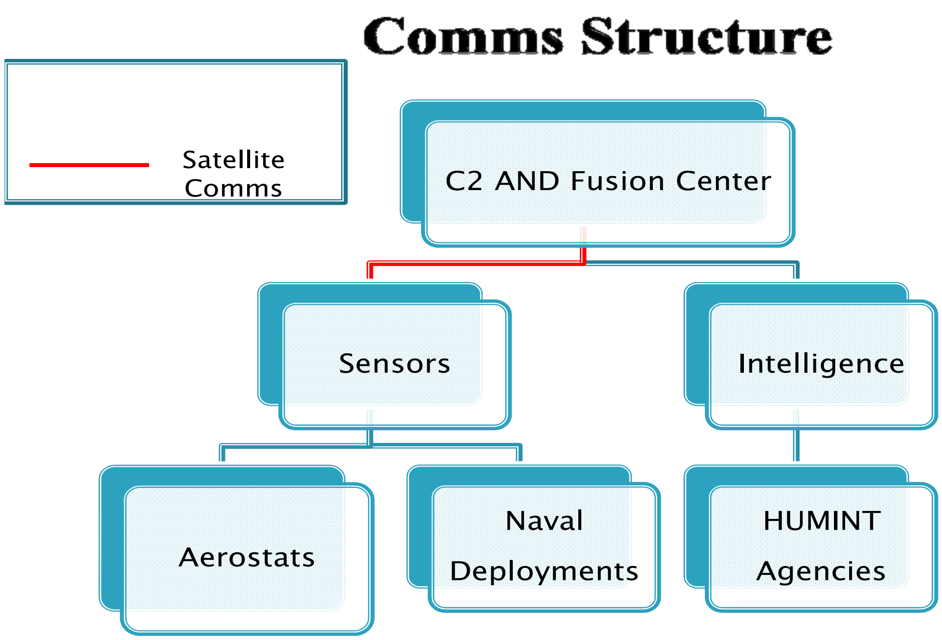

Figure 9. Proposed Communication Scheme

Figure 9 clearly depicts the structure of a hierarchical communication scheme that satisfies modern operational standards and provides flexibility as well.

G. MARITIME SCENARIOS FOR CONSIDERATION

In their book, Alberts and Hayes refer to the experimentation campaign concept as follows:

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112 Albert-Lazlo Barabasi, Linked: How everything is connected to everything else and what it means for business, science and everyday life (Plume, New York, 2003), 20–23.

> A series of related activities that explore and mature knowledge about a concept of interest. Experimentation campaigns use the different types of experiments in a logical way to move from an idea or concept to some demonstrated military capability. Hence, experimentation campaigns are organized ways of testing innovations that allow refinement and support increased understanding over time.[113]

The development of an initial concept to a concrete objective is a complicated task that requires a series of consecutive experiments structured in a logical sequence in order to reach the optimal result.

1. Pareto Efficiency

The Pareto set, along with the design parameters and the functional constraints, lay the foundation to start configuring the required maritime network to effectively support a Command and Control (C2) system that monitors a maritime domain in the wider area of the Horn of Africa. However, this does not imply that this is a static process; on the contrary, it is a dynamic process that constantly has to receive feedback in order to satisfy the rapidly increasing user needs. In particular, the network experts manage and modify when required the design variables. In other words, when dealing with practical problems, that include so many variants every optimization effort presents a great challenge. The Pareto criteria set provides a great tool for researchers aiming to address ad-hoc multi-objective optimization problems, and study the relationships between the design variables, functional constraints and the criteria constraints that evaluate whether the outcome is acceptable or not. Specifically, C2 in Maritime Interdiction Operations (MIO) is an ideal area to apply this tool since C2 is by default is dynamic and constantly evolving.[114]

[113] D. Alberts. & R. Hayes, *Code of Best Practice: Campaigns of Experimentation*, Information Age Transformation Series (Washington, DC: CCRP Press, 2005), 25.

[114] Tomoyuki Hiroyasu, Shinpei Chino, Mitsunori Miki, Flexibility of Design Variables to Pareto-Optimal Solutions in Multi Objective Optimization Problems, 4262–4468.

2. Objective

The main objective of this thesis scenario is to explore and gain further insight into how an adaptive set of sub-hierarchical networks supporting the operational use of cutting edge technological sensors (aerostats + suitable radar sensors) in conjunction with naval assets, the majority provided from regional countries (Yemen, Seychelles, Somalia, Kenya), can be utilized in the Gulf of Aden for securing the Sea Lines of Comms (SLOC) from piracy.

3. Design Variables

Network design variables are independent features that can be structured in a fashion that the best outcome is produced for the whole process. The first challenging step is to identify all the involved variables and list them in order to progress with the next steps of the procedure. Another important aspect is to fully define all the design variables in conjunction with the proper metrics. The last step provides the optimal solution to manipulate each time the design variables to optimize the final outcome.[115] The table below presents the fundamental design variables. During the whole process this work's objective was to treat the system as a whole and not as individual parts.

DESIGN VARIABLES	METRICS
Number of Platforms	Integer Number
Type of Platforms	Special features
Nodes/Clusters	Integer Number
Redundant	YES/NO
Secure Comms	1-4(Higher- Lower)

Table 4. Design Variables

[115] Tomoyuki Hiroyasu, Shinpei Chino, Mitsunori Miki, Flexibility of Design Variables to Pareto-Optimal Solutions in Multi Objective Optimization Problems, 4462–4468.

4. Functional Constraints

The functional constraints in the network offer an accurate insight into the capabilities that are available for the discussed network. Specifically, these constraints are being imposed by the surrounding environment and, if not satisfied, most likely the designed variables are neither applicable nor feasible. Conversely, this does not mean they are "a priori" fixed and cannot be negotiated. Rapid technological development is providing plenty of tools to overcome difficult situations or obstacles that in the near past seemed impossible. In our case, the functional constraints are mostly technological and economic. In the following table, four functional constraints are presented, stressing the issue of maximum bi-directional information, reliability and the economic cost of this infrastructure.[116]

NAME	DESCRIPTION	METRICS
Channel Data Rate and Channel Capacity	It is the average rate of successful message delivery over a communication channel	**It is the over a c**Mbps
Economic Cost	The overall cost / benefit analysis	Monetary
Weather	Extreme bad weather conditions will not allow the optimal utilization of the technological assets involved.	Bad Moderate Good Excellent
Activities given by the scenario	The scenario defines significantly the development and flow of the scenario each time	Level of complexity

Table 5. Functional Constraints

[116] Tomoyuki Hiroyasu, Shinpei Chino, Mitsunori Miki, Flexibility of Design Variables to Pareto-Optimal Solutions in Multi Objective Optimization Problems, 4462–4468.

The functional constrains are time and the chosen scenario. For the scenario developed in this chapter, time is constrained by the activities defined in the scenario that occur in the assigned period, and as well by the economic cost.

5. Partial Relationships for Experimentation

Alberts and Hayes usefully not hypothesize that by defining a complete set of design variables, they render their problem significantly less complex. Unfortunately, this is not true. This is inadequate because of the large number of relationships between all the variables, and that in most cases only a few relationships are thoroughly studied.[117] All of these relationships provide each respective system particular strengths and weaknesses. However, the latter situation does not always work negatively since one of the reasons for conducting experiments is to study the dynamic relationships between design variables.[118]

6. Scenario Overview

The main objective is to secure a zone that extends from 100 to 300 nautical miles from the coastal lines. For this zone, the idea is to utilize innovative technologies and concepts such as the combined use of tethered aerostats equipped with radar sensors and AIS equipment in conjunction with the support of naval assets patrolling the area. The number of assets and their level of technological development and the number, as well, of involved actors constitute the establishment of a fusion center mandatory, structured in way capable of processing all the gathered data and forward all the information towards the naval units. However, our attention remains on a wider area adjacent to the 100 nm zone off the coastline. Specifically, the area of interested is the zone between 100 and 300 nm away from the coastline of Somalia. This area could be monitored through tethered aerostats equipped with suitable radar sensors (see Fig. 11).

[117] David S. Alberts, Richard E. Hayes, *Code of Best Practice, Experimentation*, Information Age Transformation Series, (Washington, DC: CCRP Press, 2005), 24–27.

[118] Tomoyuki Hiroyasu, Shinpei Chino, Mitsunori Miki, Flexibility of Design Variables to Pareto-Optimal Solutions in Multi Objective Optimization Problems, 4462–4468.

The scenario would discuss a capacity building strategy based on a regional and an international level. However, it is important to make some crucial assumptions; otherwise, our scenario could be easily characterized as utopia. The current conditions regarding the Somali Transnational Federal Government (TFG) are quite difficult, in as much as it controls a very small percentage of the whole country. Consequently, for this scenario we assume that domestic conditions will improve at least to a level permitting the foundation of a coastguard and police.

7. Scenario Initial Experimentation Plan

In this scenario, two merchant ships considered as HVUs transit across the west coastline of Somalia. One is carrying humanitarian aid to Mogadishu, and the other is carrying radioactive material. The Maritime C2 and Fusion center receives intelligence of high credibility indicating that a pirate attack is imminent in the short term.

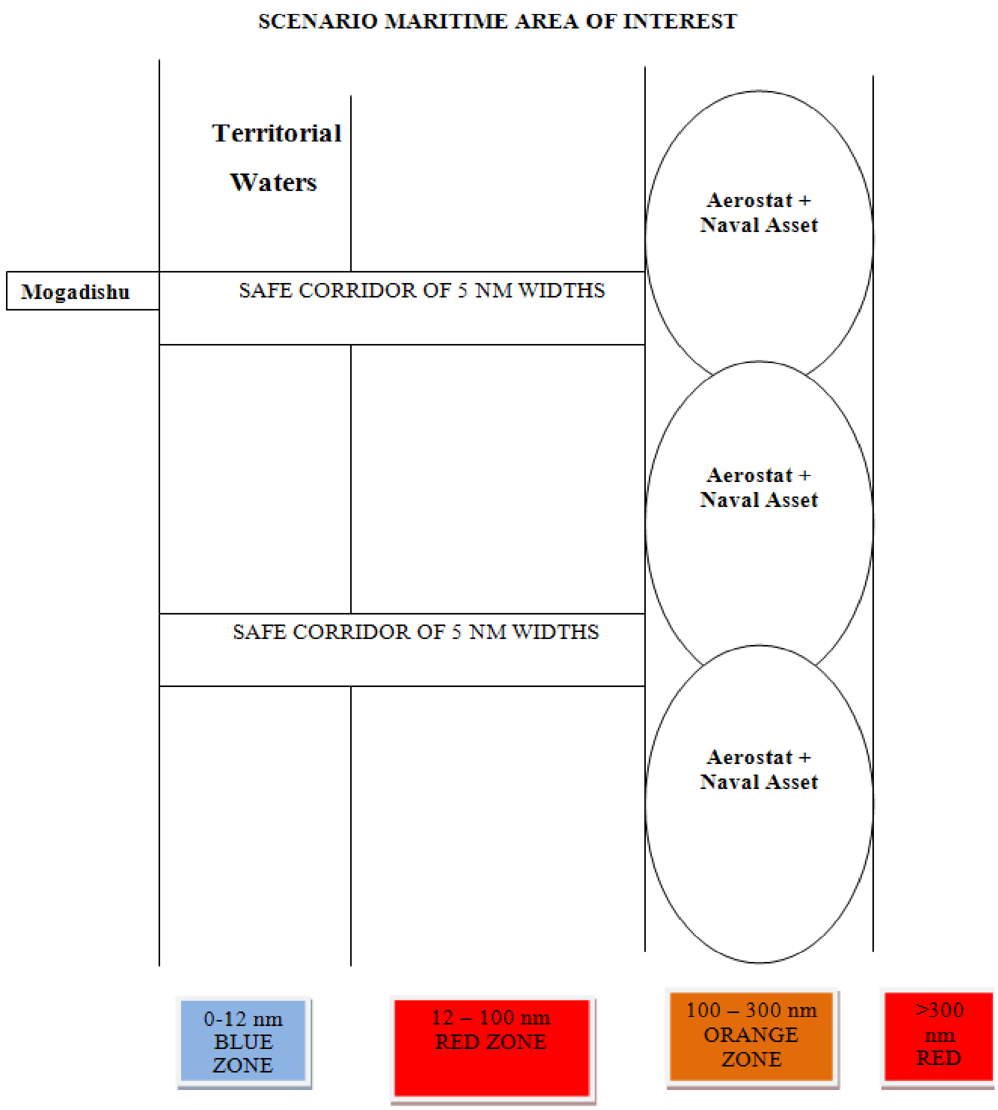

Figure 10. Graph Depicting the Area of Interest

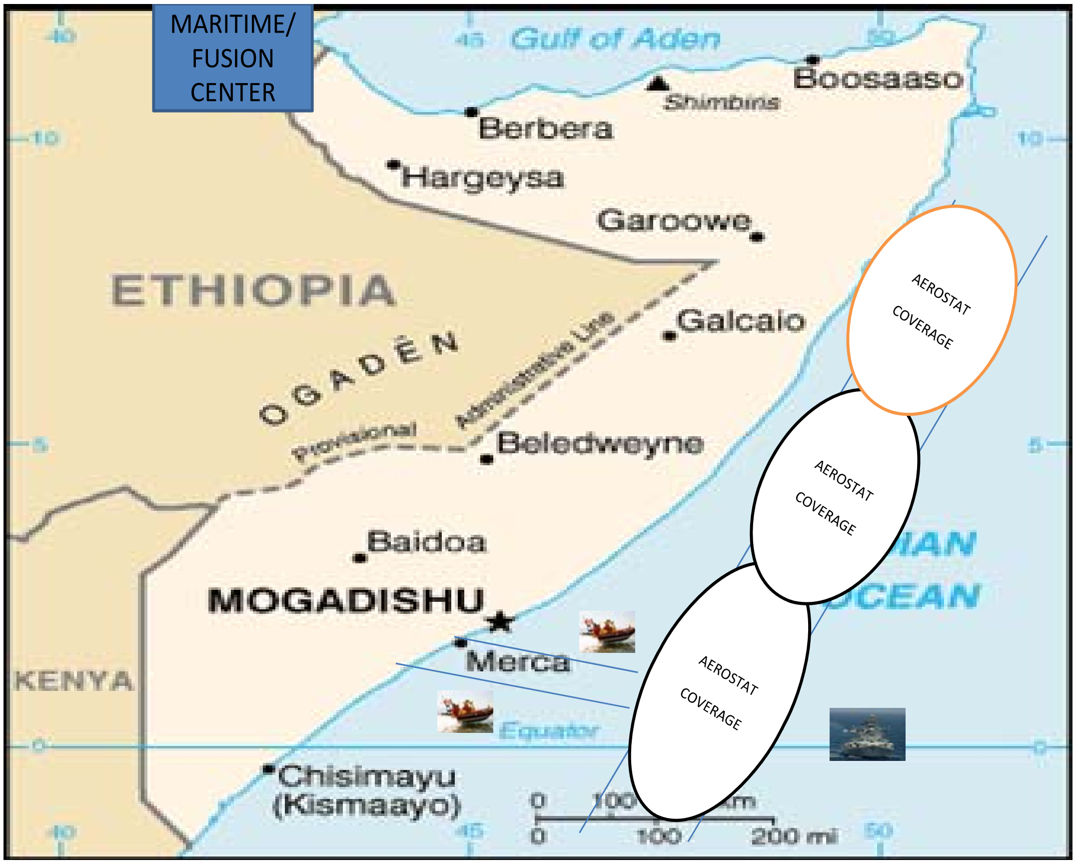

Figure 11. Schematic Depiction of the Proposed Air Monitoring System

Figures 11 and 12 offer a schematic depiction of the proposed air monitoring system with respect to the Somali coastline. This constitutes an initial approach; there is time and space to consider the exact geographic particularities and details, and since one of the main advantages of aerostat radar systems is their mobility, the discussed air monitoring system can easily be tested in other areas of need in the wider area of the Horn of Africa.

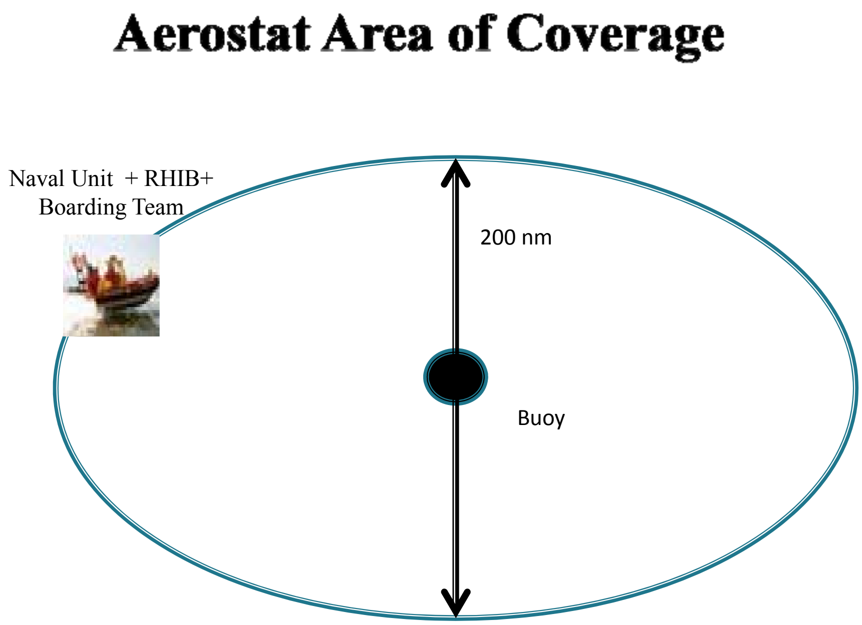

Figure 12. Footprint Aerostat Area of Coverage

As stated, the technological assets proposed in thesis work are tethered aerostats with embedded radar and AIS equipment, capable of providing an effective footprint of 200 nm. In the conceptual model described (every aerostat monitored area), a naval asset is disposed to patrol and act when the circumstances compel for it.

8. Scenario Narrative

The scenario is based on the assumption that the TFG government has assumed positive control over a small number of coastal cities; after the increase of active participation from regional institutions, i.e., the African Union, or individual neighboring countries in the level of peacekeeping contribution. There is a great incentive for the international community to deliver humanitarian aid. It is also assumed from the collection of credible intelligence indicates that there is a high possibility of pirate groups high jacking a merchant ship that carries radioactive material. Also, weather conditions are moderate. The main challenge is to maintain a constant flow of information regarding the location and the status of these HVUs and, in case of danger, to react timely.

Ship 1

A merchant ship is carrying humanitarian aid under the umbrella of the World Food Program (WFP). The ship carries a large shipment with final destination the port of Mogadishu. The ship, in accordance with IMO requirements, is equipped with an AIS transponder / receiver. The C2 Center is coordinating efforts in order for the ship to arrive safely in Mogadishu. In the event of an unidentified contact in the monitored areas, the merchant ship will be instantly notified to alter its course and a naval unit will engage the suspect vessel under orders of C2 center.

- **SHIP CHARACTERISTICS:**

  Length: 400 meters

  Width: 40 meters

  Tonnage: 100,000 tons

  Economic Speed: 14 kts

SHIP ITINERARY

TIMELINE	COURSE OF EVENTS	REMARKS
DAY 1	Ship enters the international maritime traffic corridor. Ship is monitored from the C2 center	**Speed : 14 Kts**
DAY 2	The ship continues its voyage without any interruption in the monitored areas. During the transit the C2 center collects information that pirate groups might attack a ship so, the C2 instructs to a naval asset to escort the unit and the ship to alter its initially scheduled course and proceed easterly.	**Speed : 14 Kts**
DAY 3	The ship approaches the harbor of Mogadishu under the discreet monitoring of naval deployments in the area.	

Table 6. Scenario 1 Ship Itinerary

Figure 13. Schematic Illustration of the Merchant Ship's Entrance to Mogadishu

Ship 2

- **SHIP CHARACTERISTICS:**

  Length: 450 meters

  Width: 40 meters

  Tonnage: 200,000 tones

  Economic Speed: 13 knots

The merchant ship in this case carries radioactive material. The priority for the international community is to assure safe transit of the ship and, in the event that an attack occurs, to react proactively and deter pirates from highjacking the ship. In the event of an unidentified contact in the monitored areas, the merchant ship will be notified instantly to alter its course and speed and allow the naval unit to engage the suspected vessel under the directions of the C2 center.

SHIP ITINERARY

TIMELINE	COURSE OF EVENTS	REMARKS
DAY 1	The ship enters the international maritime traffic corridor. Ship is monitored from the C2 center	Speed : 13 Kts
DAY 2	During transit, after the appearance of unidentified contacts, potential pirate mother ships, the ship alters its course and the naval asset of the respective area escorts the merchant as long as the danger of the threat lasts.	Speed : 13 Kts
DAY 3	The ship exits the International Maritime Corridor	

Table 7. Scenario 2 Ship Itinerary

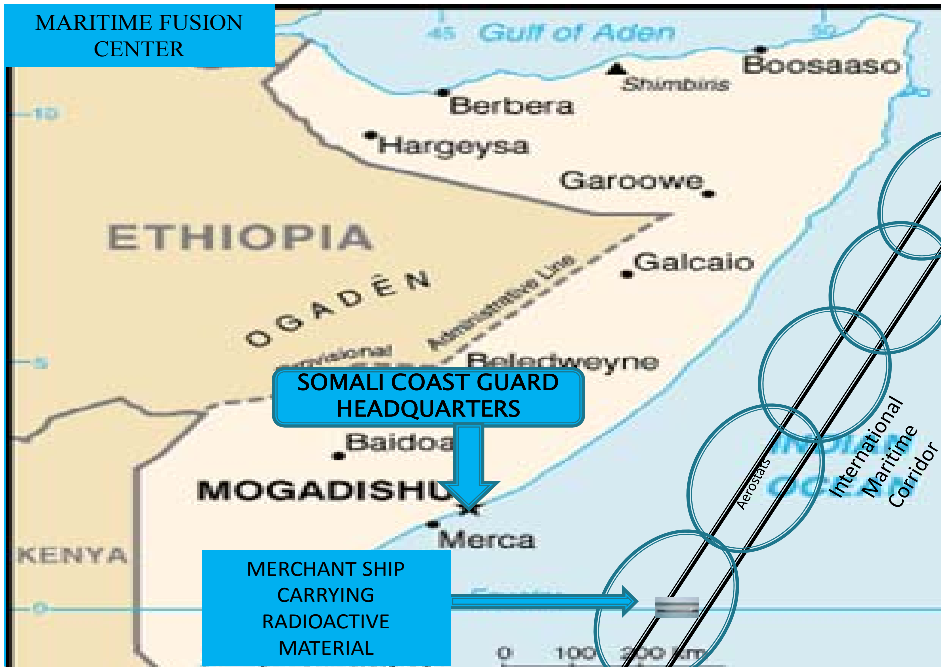

Figure 14. Schematic Illustration of the Merchant Ship's Transit

9. Criteria Constraints

The final part of a well-designed scenario inevitably includes a post-analysis phase. This is an issue of fundamental importance since it allows the evaluation of all the collected data in depth. The criteria constraints are a tool enabling involved personnel to process all the acquired data. Access feasibility is a crucial feature of this mechanism. [119]

The criteria constraints are of crucial importance since they provide the capability to determine whether the final product is acceptable in various aspects. Inverting the problem, the design and functional constraints must be structured in accordance with criteria constraints.[120] The table below is a synopsis of the criteria to be examined to determine the functionality and whether the described conceptual model can be considered as robust.

[119] David S. Alberts, Richard E. Hayes, *Campaigns of Experimentation, Pathways to Innovation and Transformation*, Information Age Transformation Series (Washington, DC: CCRP Press, 2005), 201–203.

[120] Ibid.

NAME	DEFINITION	METRICS
Average Throughput	The throughput achieved as an average	Kbps
Information Quality	Characterize the quality of the information in respect to the factor that contributed to the gathering of this information	Low-Medium-High
Overall Delay	The time difference between the expected and actual time	Minimum Time
Overall Loss	a ratio over actual and allowed loss for a given flow such as, Link Quality	Minimum
Percentage of the Unmanaged Nodes	The number of nodes outside the clusters	Minimum Integer

Table 8. Criteria constraints

The three leading principles that should dictate the data collection process are: "Validity reliability, credibility." A very important feature of this process is the access availability. [121]

H. CONCLUSIONS

It is very difficult to design an explicit, large-scale scenario, due to the fact that it is a dynamic process and always the experimentation team plays an important role in order to produce a credible outcome. However, if the previously described model is pursued the current large number of naval deployments will be significantly reduced, without compromising the operational needs and standards.

The description of the discussed conceptual model clearly promotes an alternative solution implementing innovative concepts and establishes a permanent monitoring system in the Horn of Africa. The continuation of numerous naval deployments without

[121] Alberts and Hayes, *Campaigns of Experimentation*, 187.

any perspective in the near future of ending this situation clearly signals the need for the international community to tackle this issue in a different fashion that in the long run would prove to be efficient economically and operationally.

The scenario discussed in this chapter demonstrates the potential of the conceptual model, in the problematic area in Horn of Africa and potentially before doing on the field experiments a simulation of the discussed scenario would provide a good start.[122] The statistics describing the piracy phenomenon clearly stresses the dynamic aspect of the phenomenon and how pirate groups adjust their actions in conjunction with the political developments ashore. Practically, since pirate groups operate in various areas, counter measures should not be geographically anchored but easily deployable to the areas of danger and need. Tethered Aerostats with embedded Radar sensors are inherently given this advantage, the ability to identify pirate's mother ships and suspicious patterns, and also present high potential for deployment in other areas in need of maritime surveillance.

[122] Dr. Alex Bordetsky and his research group are currently doing research work over this concept and it is highly likely to run a simulated scenario based on the concept described in this chapter.

V. COST BENEFIT ANALYSIS OF A TETHERED AEROSTAT AIR MONITORING SYSTEM

A. INTRODUCTION

A major component in all decision-making processes is the amount of funds required to transform and implement a proposed concept. Even if the outcome of a concept might be definitely positive, if the amount of money required is extremely high the concept is turned down. In particular, according to system engineering theory for a project to achieve the optimal affordability and meet the budget standards the whole process should be monitored at every step described below:

Acquisition Cost: Research, design, testing, production and Construction,

Operational Cost: Salary Cost, facilities, utilities, and energy consumption.

Product Distribution Cost: Shipping and Handling.

Software Cost: Development, operating, and maintenance software.

Maintenance Cost: Customer service, onsite personnel training, supply and reserves, test and support equipment.

Training Cost: Operator and maintenance training.

Supply Support Cost: Spares, Inventory, and Material Support.

Retirement and Disposal."[123]

The costs stated above, added together are called the Life Cycle Cost (LCC) should always be taken into account since they constitute practically the total cost of the project over its expected life cycle. Practically, the technical side is tackled first, and then the economic aspect is addressed.[124]

In sum, to analytically compute/estimate the total cost of a large technological infrastructure that utilizes assets not widely operated includes areas of uncertainty

[123] Benjamin Blanchard, S.Wolter Fabrycky, *Systems Engineering and Analysis*, Fourth Edition, Prentice Hall, New Jersey, (2006), 580–582.

[124] Ibid.

regarding the exact economic cost. Any effort to accurately estimate the total cost of the proposed air monitoring system in this thesis is subject to a lot of criticism. However, the main objective in this chapter is to provide an economic order of magnitude as a feasibility test of the whole concept to allow comparison with the current economic cost of deploying naval units in the area.

B. ECONOMIC COST OF NAVAL DEPLOYMENTS IN THE HORN OF AFRICA

In 2008, there was a dramatic increase in piracy incidents. The international community was forced to act immediately and decisively to secure the Sea Commons in the Gulf of Aden by heavily deploying naval assets in the area. In particular, more than 30 countries under the leadership of the United States have formed CTF 151, a coalition with the ultimate objective of fight maritime terrorism, including piracy in the Middle East. [125] In 2009 the total number of naval ships participating in anti-piracy efforts was around thirty, all year long on a 24/7 mission. [126]

Any effort to compute the precise economic cost of the naval deployments in the area inevitably will include an area of uncertainty, since there are always indirect costs that cannot be accurately defined.[127] On the other hand, due to the massive deployment of naval assets, from various organizations an estimate of the total economic cost is feasible. The average deployment cost of a frigate size ship is estimated to be around $1.3 million per month.[128] Since the average number of ships patrolling in the area is thirty, we can conclude that a minimum cost of the deployments in the area is around $40 million per day. [129]

[125] United States Government Accountability Office (GAO), Maritime Security, Actions Needed to Assess and Update Plan and Enhance Collaboration among Partners Involved in Countering Piracy off the Horn of Africa, September 24, 2010, 2.

[126] Ibid.,22.

[127] Ibid.,33.

[128] Chalk, *Maritime Piracy off the Horn of Africa*.

[129] Ibid.

Indicative also of the cost of fighting piracy in this fashion is that in 2009 the EU spent approximately $450 million supporting operation Atalanta (EUNAVFOR).[130] The U.S., in fiscal year 2009, spent $64 million through Central Command supporting US flagged ships patrolling in the HoA.[131] In addition to the cost above is the cost originating from ships deployed by independent countries to tackle piracy.

The economic cost of the naval deployments discussed above raises important questions. In particular, the total economic cost of naval deployments fighting piracy every month is above $1 billion dollars. Another indirect cost that should be eluded is the opportunity cost for the contributing countries, since for every country would be different. In particular the reduction of naval units patrolling in the area would offer the countries an option of deploying their assets in other areas where their national interests are in stake.

A high economic cost of that magnitude generates a sustainability issue in the long run since many countries now contributing forces most likely would not have the capacity to contribute forces for a long period of time, in light of the economic recession that is impacting a great number of countries.[132]

C. ECONOMIC COST OF PROPOSED AIR MONITORING SYSTEM

The computation of the exact economic cost is a complex process that overwhelms the scope of this thesis; however, it is important to present an economic outline of the proposed air monitoring infrastructure in order to present the feasibility and the economic benefits of adopting a capacity building strategy that utilizes the discussed innovative technological assets.

In particular, the costs involved have to do with the procurement, operating and support costs. Even with the large number of uncertainties, the procurement cost of the balloons varies from $20 to $100 million, depending on the size and the offered set of

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[130] Chalk, *Maritime Piracy off the Horn of Africa*.

[131] GAO, Maritime Security, Actions Needed to Assess and Update Plan and Enhance Collaboration among Partners Involved in Countering Piracy off the Horn of Africa, 33.

[132] Chalk, *Maritime Piracy off the Horn of Africa*.

capabilities of the payloads.[133] Furthermore, an important component of these advanced technological assets is the embedded sensor, for which a reasonable estimate is $20 million.[134] In addition, the operating and supporting cost is estimated to be in the range of hundreds of dollars of per hour. Consequently, considering the most demanding scenario of a 24/7 operation for 365 days, the supporting and operating cost is in the range of million dollars per year. For example, if the cost is $700 hundred an hour the total annual cost reaches approximately $6 million per year. [135]

However, apart from the stand alone economic analysis, there is an imperative need to include an operational component in this pursuit and, in particular, with issues related to the maritime domain and specifically the efficiency in regards to maritime surveillance.

An approach that seems to offer an accurate depiction of the economic benefits of the discussed innovative assets in maritime surveillance is the cost to cover one square km; the ratio between the economic cost ($) and the covered area ($m^2$). Aerostats with embedded radar sensors as payloads can maintain an effective footprint of 150 nm radius, as opposed to radar sensors carried by naval units that provide an effective coverage that reaches a surveillance circle with a radius of 30 nm.

The next step is to compare the two methods of surveillance on an economic basis in order to determine whether there is potential in introducing this out-of-the-box approach as a countermeasure against piracy. An average cost per year including support and operating costs is approximately $6 million. Consequently, the discussed ratios are approximately:

For an aerostat: $\$6\ M / \pi * (150)^2 = \$85 / km^2$

For a ship: $\$12 * 1.3M / \pi * (30)^2 = \$5520 / km^2$

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[133] Israeli Aerostats for India, *America at War,* http://afpakwar.com/blog/archives/425 (2009), (accessed on 15 October 2010).

[134] Israeli Aerostats for India, *America at War*.

[135] Inside the Navy, *Navy Eyes Aerostats for Affordable Long Duration Surveillance*, http://www.tcomlp.com/resources/TCOM%20Inside%20the%20Navy%20Reprint%2012-06.pdf, (accessed on September 2010).

The ratio between the figures computed above is 0.18, which is rather indicative of the economic benefits in adopting a new model to accomplish maritime surveillance. On the other hand, considering that the minimum cost for a ship operating in the area is $1.3 million per month and there are more than 25 ships patrolling in the area. The average annual cost of naval deployments exceeds $10 billion. In addition to the previously stated cost , the economic cost from the ransom should be taken also into account into particular the Somali pirated have collected an amount which exceeds $100 million since 2007, since the ship owner policy is supporting piracy by paying ransom fees.[136]

D. CONCLUSIONS

This chapter demonstrated the comparative advantage of developing an air monitoring system to address the issue of piracy in contrast to the traditional deployments of naval assets in the troubled area. However, the development of this economic approach inevitably included a large number of uncertainties and many assumptions must be considered. Regardless of the number of uncertainties and assumptions, we know from experience that the contemporary method of addressing piracy despite the high economic cost produces only moderate operational results as it has been statistically demonstrated over the last years.

In the introduction of this chapter it has been stated that the distance between a concept and the final implementation of a concept is tremendous; however the cost benefits from adopting a similar model clearly promotes the continuation of this research and provides the necessary momentum for further research and development. Even a partial adoption of the described model would provide significant economic benefits for all the players involved. However, it is important to keep in mind that the deployment of an air monitoring system of that magnitude is a long time commitment and the great challenge for the international community is to increase the level of participation from regional institutions and countries. Unfortunately, this prospect presents significant hazards since the political situation in the majority of these countries is very fragile, and a lot of attention is required for the regional players to be involved.

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[136] GAO, Maritime Security, Actions Needed to Assess and Update Plan and Enhance Collaboration among Partners Involved in Countering Piracy off the Horn of Africa, 1.

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VI. CONCLUSIONS AND RECOMMENDATIONS

The issue of piracy, despite the international interest it has received and the actions taken by the international community, in particular the deployment of naval forces, remains on the agenda and requires even more attention and action from international global players. Indicative of the serious escalation of the issue is the dramatic increase of piracy incidents in the wider area of the Horn of Africa and in other areas like the South China Sea, and off the Nigerian coasts. The current situation has led pirate groups to operate in areas out of reach from naval patrols and in neighboring seas. The current method of tackling piracy by sending naval forces is partially effective, but at the same time causes a great economic burden that exceeds the one billion dollars per month.

The rise of piracy in the security agenda has brought to the table a whole new question of determining the optimal capacity building strategy to address piracy considering that pirate groups have adopted new tactics and take advantage of the political instability in Somalia and in neighboring countries. The domestic politic situation does not allow any drastic action on a domestic level to fight pirates. However this does not mean that the existing political entities in Somalia (Somaliland and Puntland) should not be supported in regards to equipment and "know how in strengthening local institutions like coastguard and police. Consequently, the strategic importance of sea commons would eventually force the international community to successfully address this phenomenon by utilizing cutting edge technological assets and implementing innovative operational concepts.

Regarding piracy, the international community should try to think innovatively and integrate operational concepts that can meet the challenges of piracy nowadays, considering the occurrence of piracy attacks in a large number of areas that cannot be predicted. In particular, a network of balloons with embedded radar sensors and AIS equipment offers an easily deployable solution in conjunction with a supporting intelligence policy would lead to augmented ISR capabilities constituting an advanced anti-piracy tactic.

Since political instability in the wider area of the Horn of Africa is common and the prospect of overcoming this political problem does not appear in the near future, a different capacity building strategy should be pursued. The main objectives of the capacity-building strategy presented in this thesis focuses on utilizing innovative technological assets that are easily deployed, not geographically anchored, and, in addition, offer augmented ISR capabilities. Technological assets incorporating all the previously discussed features are tethered aerostats with embedded sensors, specific UAVs and satellite assets. Despite the virtues of the discussed proposed capacity model it should always be kept in mind that a long time commitment is required and the goal during this whole process should be to achieve the highest level of contribution from regional players. An important feature of the cutting- edge technological assets presented in this thesis is the comparatively low economic cost that justifies the continuation of the research in this field despite the fact that in the end the capacity model described might not be the one adopted.

The scenario discussed in this thesis aims to demonstrate the feasibility of the proposed conceptual model and how it could be applied in securing maritime corridors. However, since the economic aspect is a catalyst, an initial economic approach was attempted in order to determine whether there is any potential in further pursuing a potential application of the described model. Despite the fact that this approach included a significant number of uncertainties and assumptions, it finally yielded to promising results, economic wise. Consequently, the continuation of this research is more than welcome since even a partial adoption of the discussed model would provide significant economic benefits and in addition allow the involved countries to deploy their assets in other areas of need where their national interests compel for the deployment of naval assets.

Finally, it is important to consider that with the complicated contemporary political agenda in countries where piracy occurs, it is very difficult to totally eliminate piracy incidents; however the goal should be the drastic reduction of piracy incidents due to the severity of the political and economic bi-products.

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