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Capacity Building as an Answer to Piracy in the Horn of Africa

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Track 1: Concepts, Theory, and Policy

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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 paper 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.

Introduction

The last two decades, the Horn of Africa (HoA) has become the epicenter of interest for the global community due to the drastic increase in piracy. 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. 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. The international community in contemporary times is facing serious challenges in many domains. The only tool historically proven capable of addressing these challenges is **Capacity Building.**

The major research question this paper attempts to answer is the following:

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

1. 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 [1]." 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. Geography plays an important role [2]. 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 [2].

2. CAPACITY BUILDING IN THE HoA

The causal factors of piracy in the HoA clearly demonstrate 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* [3] .

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 [4]. 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 [4].

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 [4].

However, the impact of piracy is global and its cost is estimated to be in the range of 0.5 -1 $billion annually. 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.

Capacity building against piracy, as has been eluded previously, should have a domestic, regional, and international component. Consequently, a modern antipiracy strategy should entail an “innovative non-kinetic policy [5].” In particular, this paper 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. Specifically, consolidating all anti-piracy efforts under one command would significantly boost the efficiency of the disposed naval patrolling forces in the area [5]. Furthermore, this paper 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. 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. 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* [6].”

The first step against piracy 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 institutions, i.e., coastguard and police, and their efforts should be supported [5]. 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. 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 [5].

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. Although more than 30 countries have deployed naval forces, in 2009 there was an increase in piracy attacks, reaching 196 attacks [7]. Furthermore, as it was eluded previously, 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 and aims in employing cutting edge technological assets as the ones described below.

3. TETHERED AEROSTAT RADAR SENSORS

a. 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. 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 [8].

b. 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* [8]."

The majority of hulls are manufactured out 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 [8].

c. 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 modern security issues is to create sea-based assets able to detect and identify threats in a timely manner [8]. The role that seems fit for aerostats is "persistent surveillance"; this paper proposes a conceptual model, which consists of an air monitoring system for high-traffic maritime zones [9].

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. 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. 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 [8]. However, a caveat when utilizing aerostats is that they are affected when strong winds are blowing. 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 [8].

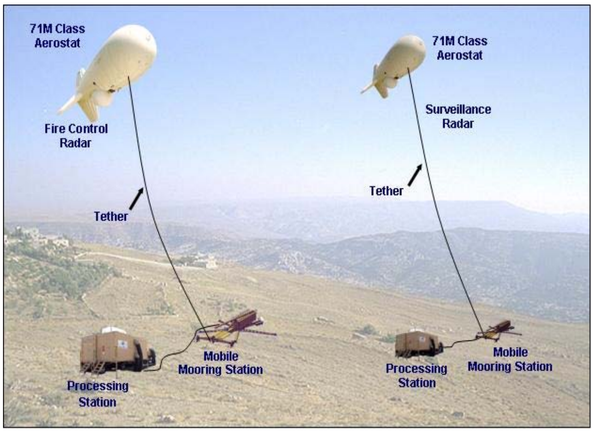

Figure 1. JLENS schematics

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. 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 [10].

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 [10].

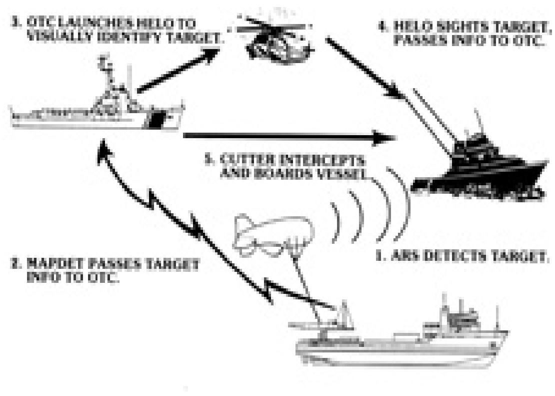

Figure 2. The operational concept when deploying ships with an embedded radar system (From [10])

Figure 2 illustrates 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 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 [10].

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. However, EL/M 2083 radar mainly function is against low fast moving aircraft [11]. 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. 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 [11].

4. UNMANNED AERIAL VEHICLES (UAVS)

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* [12].” Future advanced maritime networks involve a comprehensive set of “air assets, manned and unmanned, and sea-based and land-based assets [12].”

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

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 [13].

Figure 3. Vellerofontis during a flight carrying a camera streaming video (from [13])

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 1 [13]:

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

Table 1. Vellerofontis operational characteristics

Vellerofontis includes these promising capabilities [13]:

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. 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. 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 [13].

5. Maritime scenario

A. PURPOSE

The main scope of the scenario described 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

B. 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 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* [14]."

2. Maritime Command and Control Fusion Center

The infrastructure discussed in this paper 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.

C. 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* [15].

This paper 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 born 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 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* [16]."

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 [17]. 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 [17] ".

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) [18].

D. 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 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 [20].

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. The set of these procedures and rules is officially described as a communication protocol. Furthermore, a key aspect of this agreement between layers is the interface used each time the layers communicate [20].

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* [12]."

E. 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 [14]."

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 [21]." 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.

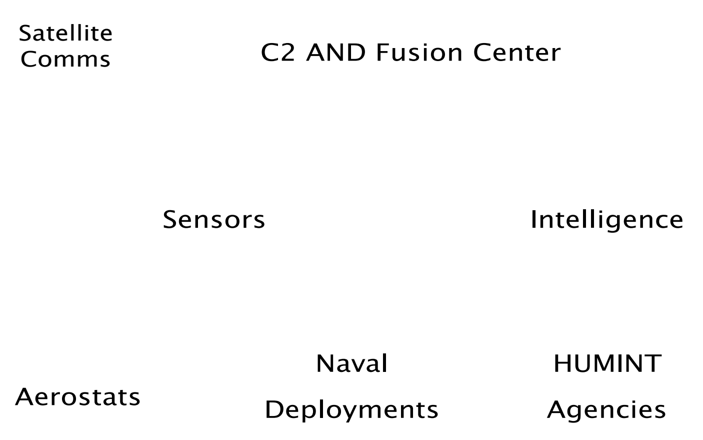

Figure 4. Proposed Communication Scheme

Figure 4 clearly depicts the structure of a hierarchical communication scheme that satisfies modern operational standards and provides flexibility as well.

F. MARITIME SCENARIOS FOR CONSIDERATION

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

> "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 [18] ".

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 [20]. 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 [20].

2. Objective

The main objective of this 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. The table below presents the fundamental design variables. During the whole process this paper's objective was to treat the system as a whole and not as individual parts [21].

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 2. Design Variables

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 [21]. 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.

NAME	DESCRIPTION	METRICS
Channel Data Rate and Channel Capacity	It is the average rate of successful message delivery over a communication channel	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 3. Functional Constraints

The functional constrains are time and the chosen scenario. For the scenario developed in this paper, 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 have usefully argued that by defining a complete set of design variables, they render their problem significantly less complex. Unfortunately, this is valid is because of the large number of relationships between all the variables, and that in most cases only a few relationships are thoroughly studied. 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 [18]-[21].

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. 5).

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.

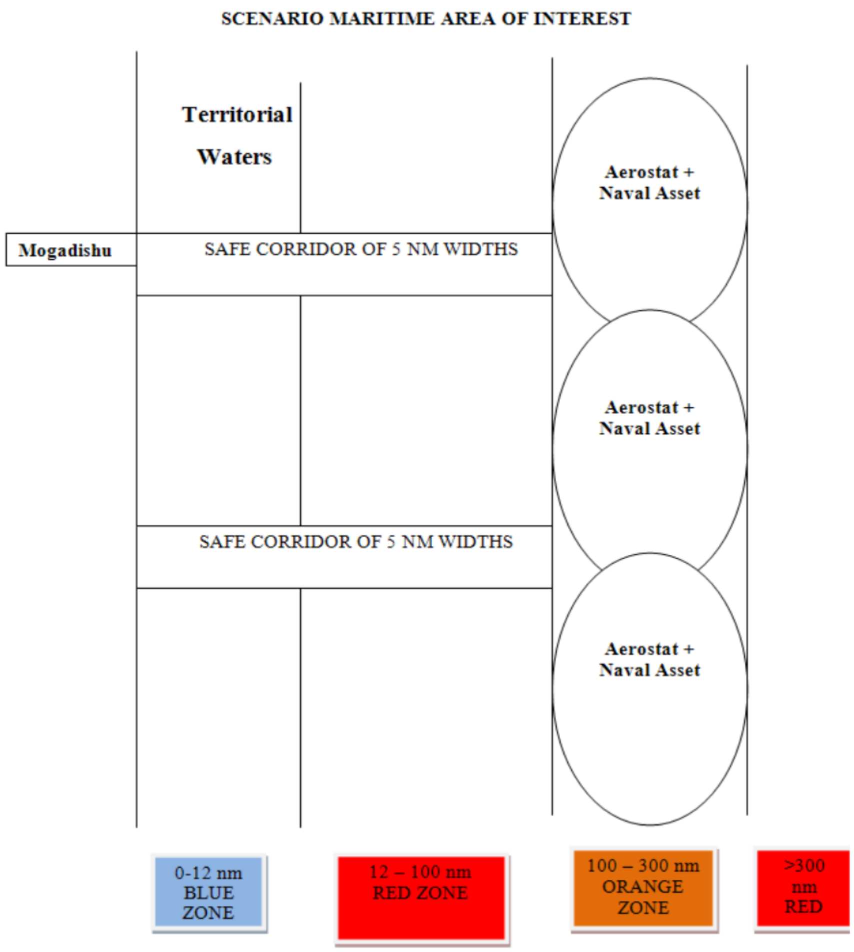

Figure 5. Graph Depicting the Area of Interest

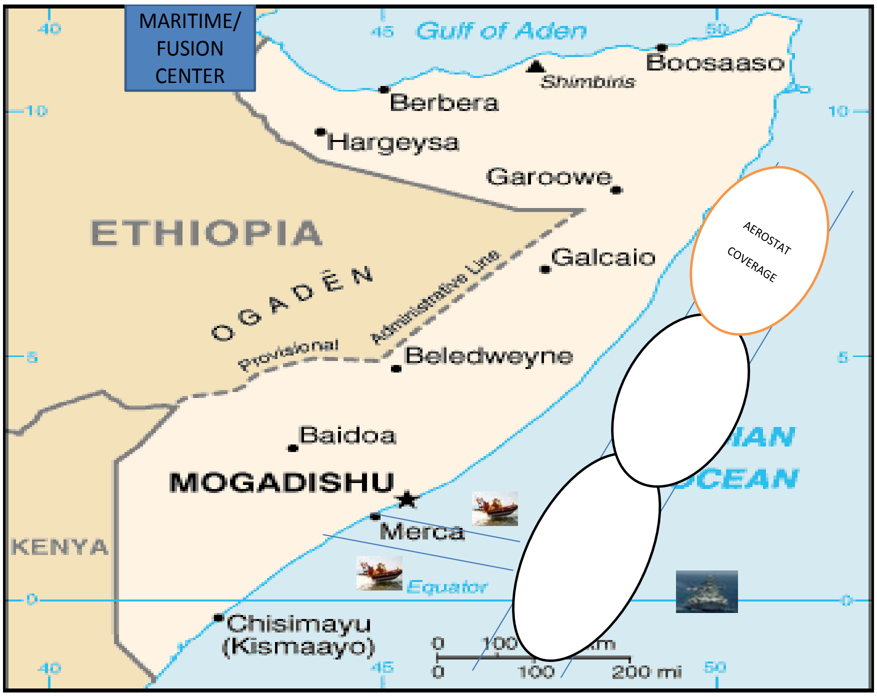

Figure 6. Schematic Depiction of the Proposed Air Monitoring System

Figures 5 and 6 offer a schematic depiction of the proposed air monitoring system with respect to the Somali coastline. This constitutes an initial approach; there is room and space to consider the exact geographic particularities and details, and since one of the main advantages of aerostat radar systems is their mobility

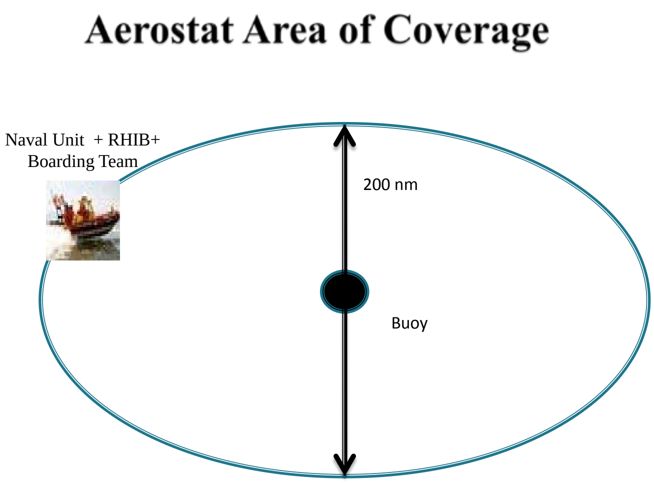

Figure 7. Footprint Aerostat Area of Coverage

The main technological assets proposed in this paper 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	**Speed : 14 Kts**

	and proceed easterly.	
DAY 3	The ship approaches the harbor of Mogadishu under the discreet monitoring of naval deployments in the area.	

Table 4. Scenario 1 Ship Itinerary

Figure 8. 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 high jacking 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 5. Scenario 2 Ship Itinerary

Figure 9. 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 [18].

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. 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 [18].

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 6. 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 [18].

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

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 [19]."

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. In sum, to analytically compute/estimate the total cost of a large technological infrastructure that utilizes assets not widely operated includes areas of uncertainty regarding the exact economic cost. Any effort to accurately estimate the total cost of the proposed air monitoring system in this paper is subject to a lot of criticism [19].

A. 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. In 2009 the total number of naval ships participating in anti-piracy efforts was around thirty, all year long on a 24/7 mission [23].

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. 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. 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 month [23].

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) The U.S., in fiscal year 2009, spent $64 million through Central Command supporting US flagged ships patrolling in the HoA. In addition to the cost above is the cost originating from ships deployed by independent countries to tackle piracy [23].

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 exceeds $ 0.5 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 [23].

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.

B. ECONOMIC COST OF PROPOSED AIR MONITORING SYSTEM

The computation of the exact economic cost is a complex process that overwhelms the scope of this paper; 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 capabilities of the payloads. Furthermore, an important component of these advanced technological assets is the embedded sensor, for which a reasonable estimate is $20 million. 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 [9].

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 [23].

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

The ratio between the figures computed above 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 $ 0.5 billion [23]. 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 [23].

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 amount of one billion dollars per month [23].

6. CONCLUSIONS

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 paper 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 paper 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 allows 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.

LIST OF REFERENCES

[1] Riggs, Stephen. *Piracy in the Horn of Africa: A Comparative Study with Southeast Asia*. Monterey, CA: Naval Postgraduate School, 2009.

[2] Hansen, Stig Jarle. *Piracy in the Greater Gulf of Aden: Myths, Misconception and Remedies*. Oslo, Norway: Norwegian Institute for Urban and Regional Research, 2009, http://www.nibr.no/uploads/publications/26b0226ad4177819779c2805e91c670d.pdf (accessed August 20, 2010).

[3] Business Dictionary.com. "Capacity Building." http://www.businessdictionary.com/definition/capacity-building.html (accessed August 10, 2010).

[4] Kline, Jeff. "Maritime Security." In *Securing Freedom in the Global Commons*, edited by Scott Jasper, 67–82. Stanford, CA: Stanford University Press, 2010.

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

[6] "NATO Maritime Interdiction Operational Training Centre (NMIOTC)." NATO, *Training Areas and ACT Courses,* http://www.hellenicnavy.gr/nmiotc/index_en.html (accessed August 12, 2010).

[7] International Maritime Bureau of the ICC. *Piracy and Armed Robbery against Ships: Annual Report*, *January 1– December 31*, *2009*. Barking, Essex: ICC International Maritime Bureau, 2010.

[8] Bolkcom, Christopher C. *Potential Military use of Airships and Aerostats*. CRS Report RS21886. Washington, DC: Congressional Research Service, Library of Congress, 2004, http://www.fas.org/man/crs/RS21886.pdf (accessed August 20, 2010).

[9] Navy Eyes Aerostats for Affordable, Long-Duration Surveillance. *Inside the Navy*, December 11, 2006. http://www.tcomlp.com/resources/TCOM%20Inside%20the%20Navy%20Reprint%2012-06.pdf (accessed August 20, 2010).

[10] United States Coastguard, Aerostat Program, http://www.uscg.mil/history/articles/aerostat.asp , (accessed August 20, 2010).

[11] India Buys Israeli Aerostat Radar. *Air Defense*, January 23, 2009. http://www.strategypage.com/htmw/htada/20090123.aspx (accessed October 11, 2010).Department of the Air Force. "Fact Sheet: Tethered Aerostat Radar System." Air Combat Command Public Affairs. http://www.acc.af.mil/library/factsheets/factsheet_print.asp?fsID=2359&page= (accessed September 29, 2010).

[12] United States. Office of the Chief of Naval Operations. *Naval Transformation Roadmap 2003: Assured Access & Power Projection—from the Sea*. Washington, DC: U.S. Navy, Chief of Naval Operations, 2003, http://permanent.access.gpo.gov/lps50241/document_358_NTR_Final_2003.pdf (accessed August 20, 2010).

[13] Koukos, Ioannis. "Maritime Situational Awareness through Unmanned Mini Helicopter." *NMIOTC Journal* 1, no. 1 (February 2010): 20–22.

[14] Buschmann, Jeff, 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).

[15] "Guilio Douhet." Comando Supremo Italy at War. http://comandosupremo.com/douhet.html (accessed September 19, 2010).

[16] Schleher, D. Curtis. *Electronic Warfare in the Information Age*. Artech House Radar Library. Boston, MA: Artech House, 1999.

[17] Konstantinos, Tsakonas. "Importance of Future Networks and Capabilities for Maritime Security." *NMIOTC Journal* 1, no. 1 (February 2010): 22–25.

[18] Alberts, David S. and Richard E. Hayes. *Code of Best Practice for Experimentation*. CCRP Publication Series. Washington, DC: DoD, 2002, http://www.dodccrp.org/files/Alberts_Experimentation.pdf.

[19] Blanchard, Benjamin S. and W. J. Fabrycky. *Systems Engineering and Analysis.* 4th ed. Upper Saddle River, NJ: Pearson Prentice Hall, 2006.

[20] Alexandrou, Marios. "Network Protocol Hierarchy Definition." http://www.mariosalexandrou.com/definition/network-protocol-hierarchy.asp (accessed August 20, 2010).

[21] Barabási, Albert-Laszló. *Linked: How Everything is Connected to Everything Else and what it Means for Business, Science, and Everyday Life*. New York: Plume, 2003.

[22] Hiroyasu, Tomoyuki, Shinpei Chino, and Mitsunori Miki. "Flexibility of Design Variables to Pareto-Optimal Solutions in Multi Objective Optimization Problems." In *IEEE Congress on Evolutionary Computation, 2007 (CEC 2007)*, 4462-4468. Piscataway, NJ: IEEE, September 25–28, 2007, Singapore.

[23] United States. Government Accountability Office. *Maritime Security: Actions Needed to Assess and Update Plan and Enhance Collaboration among Partners Involved in Countering Piracy Off the Horn of Africa*. Washington, DC: US Govt. Accountability Office, 2010, http://www.gao.gov/new.items/d10856.pdf (accessed August 20, 2010).