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NEW NAVY FIGHTING MACHINE IN THE SOUTH CHINA SEA

by

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Through the perspective of Wayne P. Hughes' missile salvo equation, this research examined naval surface forces of the People's Republic of China (PRC) and the United States (U.S.) in order to demonstrate how American surface combatants can defeat PRC anti-access area denial (A2AD) measures in the South China Sea (SCS). Hughes' equation reveals that advantages for American surface forces are obtained by increasing fleet numbers, counter-targeting (CT), and increased scouting. This thesis advocates fleet growth as articulated in Hughes' New Navy Fighting Machine (NNFM) study. Comparisons of the NNFM, the U.S. fleet, and the PRC fleet demonstrate both the disparity facing the American surface forces, and the near parity obtained in the NNFM. CT through unmanned surface vehicles (USVs), and naval obscurants provide American surface forces increased staying power and tactical advantage. Scouting and communications networking through a theater wide constellation of airships provide the American fleet with persistent situational awareness of the battle space, tactical communications with subsurface forces, and improved emissions control (EMCON) measures for surface forces. The distributive properties of the NNFM, combined with this study's CT and scouting findings, offer American surface combatants success over the PRC Navy in the SCS scenario.

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NEW NAVY FIGHTING MACHINE IN THE SOUTH CHINA SEA

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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

A2AD	Anti-Access Area Denial
AAC	Air-to-Air Combat
AAD	Anti-Aircraft Defense
AGC	Automatic Gain Control
AGS	Advanced Gun System
ARIES	Airborne Reconnaissance Integrated Electronics Suite
ASCM	Anti-ship Cruise Missile
ASM	Air-to-Surface Missile
ASW	Anti-Submarine Warfare
AWACS	Airborne Warning and Control System
BDII	Blue Devil Block II
BLOS	Beyond Line of Sight
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CEP	Circular Error Probability
CFAR	Constant False Alarm Rate
CG	Guided Missile Cruiser
C-IED	Counter Improvised Explosive Device
CMS	Canister Missile System
CNA	Center for Naval Analyses
COCOM	Combatant Commander
CONUS	Continental United States
COP	Common Operating Picture
CRS	Congressional Research Service
CSG	Carrier Strike Group
CT	Counter-targeting
CTOL	Conventional Takeoff and Landing
CV	Aircraft Carrier
CVL	Small Aircraft Carrier

CVN	Nuclear Powered Aircraft Carrier (Carrier, aviation, Nuclear)
CUSV	Common USV
DC	Damage Control
DCA	Defensive Counter Air
DDG	Guided Missile Destroyer
DoD	Department of Defense
DoN	Department of the Navy
DTIC	Defense Technical Information Center
EEZ	Economic Exclusion Zone
EMCON	Emissions Control
EM	Electro-Magnetic
EMP	Electro Magnetic Pulse
EO	Electro-Optical
EO/IR	Electro-Optical/ Infra-red
ES	Electronic Support
ESSM	Evolved Sea Sparrow Missile
EW	Electronic Warfare
FAC	Fast Attack Craft
FALCON	Fast Airborne Laser Communications Optical Node
FFG	Guided Missile Frigate
FRC	Fast Response Cutter
FSM	Fast Steering Mirror
Gbps	Gigabit-per-Second
GIG	Global Information Grid
GPS	Global Positioning System
HMS	Her Majesty’s Ship
HTA	Heavier-than-Air
HVU	High Value Unit
IED	Improvised Explosive Device
IFF	Identification, Friend or Foe
INS	Inertial Navigation System

IPL	Integrated Priority List
IR	Infra-red
ISO	International Organization for Standards
ISR	Intelligence, Surveillance, and Reconnaissance
JIEDDO	Joint Improvised Explosive Device Defeat Organization
JWICS	Joint Worldwide Intelligence Communications Systems
Kts	Knots
LCS	Littoral Combat Ship
LOS	Line of Sight
LPDI	Low Probability Detection Interception
LTA	Lighter-than-air
M	Meters
MCM	Mine Counter Measure
Mi	Mile
MIO	Maritime Interdiction Operations
MMW	Millimeter Wave
MOC	Maritime Operational Command
MRBM	Medium Range Ballistic Missile
NATO	North Atlantic Treaty Organization
NM	Nautical Mile
NNFM	New Navy Fighting Machine
NPS	Naval Postgraduate School
OPSEC	Operational Security
OSD	Office of the Secretary of Defense
OTHT	Over the Horizon Targeting
PLA-N	People’s Liberation Army - Navy
PRC	People’s Republic of China
QDR	Quadrennial Defense Review
RCS	Radar Cross Section
RF	Radio Frequency
ROE	Rules of Engagement

ROVER	Remotely Operated Video Enhanced Receiver
SA	Situational Awareness
SAG	Surface Action Group
SAM	Surface-to-Air Missile
SCN	Ship Construction Navy
SCS	South China Sea
SDC	Space Data Corporation
SIGINT	Signals Intelligence
SOF	Special Operations Forces
SRBOC	Super Rapid Blooming Offboard Chaff
SSM	Surface-to-Surface Missile
SUW	Surface Warfare
TacAir	Tactical Air
TACAMO	Take Charge and Move Out
TAN	Theater Area Network
TCDL	Tactical Common Data Link
TEL	Transporter-Erector-Launcher
TNT	Tactical Network Topology
TTNT	Tactical Targeting Networking Technology
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
USAF	United States Air Force
USN	United States Navy
USNS	United States Naval Ship
U.S.	United States
USCG	United States Coast Guard
USS	United States Ship
USV	Unmanned Surface Vehicle
VLF	Very Low Frequency
WAAS	Wide-Area Airborne Surveillance Sensors

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-Jimmy

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I. INTRODUCTION

The purpose of this thesis is to demonstrate how American surface forces can defeat potent Chinese anti-access area denial (A2AD) measures in the unfortunate event of conflict in the South China Sea (SCS). To focus this thesis, only the contributions of the People's Republic of China (PRC) and the United States (U.S.) naval surface forces are addressed. The setting, the SCS, requires one to consider predominantly the inputs of maritime assets.[1] Improving America's chance at success lies in understanding the factors of naval warfare as delineated by Wayne P. Hughes' missile salvo equation.[2] Following discussions of those factors, improvements to the fleet based on exploiting such elements are presented. To frame the topic, political and naval considerations affecting China and America are examined. It is determined that American disadvantages caused by apprehension to losing potential capital ships and an aversion to striking first can be surmounted by the distributed composition of the New Navy Fighting Machine (NNFM) study[3] as employed in this thesis.

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[1] "China's growing military and economic weight is beginning to produce a more assertive posture, particularly in the maritime domain." Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2011* (Washington, DC: Office of the Secretary of Defense, 2011) 15.

[2] For a complete discussion on modern naval warfare see: Wayne P. Hughes, Jr., *Fleet Tactics and Coastal Combat* (Annapolis, MD: Naval Institute Press, 2000).

[3] For a complete discussion on a more distributed fleet see: Wayne P. Hughes, Jr., "The New Navy Fighting Machine: A Study of the Connections Between Contemporary Policy, Strategy, Sea Power, Naval Operations, and the Composition of the United States Fleet" (Monterey, CA: Naval Postgraduate School).

A. CONSIDERATIONS FOR POTENTIAL ARMED CONFLICT

1. International Contention in the South China Sea

The western Pacific is home to many areas of growing contention. In the past, a predominant concern of the U.S. centered upon potential PRC military aggression towards Taiwan. However, speculation over oil and gas reserves embedded in the SCS has increasingly drawn attention to the waters between Vietnam and the Philippines. Claims assertions have already generated tensions between Southeastern Asian neighbors and have the potential to grow into armed conflict as the PRC increases their level of force within the region.[4] Involvement in the SCS region is intended to uphold international maritime law[5] and the rights of countries less able to defend themselves.

a. PRC's SCS Perspective

Beginning in 1935, government sources within China began drawing charts with dashed lines surrounding the SCS declaring those waters distinctively China's.[6] In 1949, the PRC published maps similar to the one seen in

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[4] "For states that ring the South China Sea, its waters represent a zone of rich hydrocarbon and protein resources that are increasingly dear on land as populations exhaust their territories' ability to meet their increasing needs. This resource competition alone could be the basis of sharp-edged disputes between the claimants." Peter Dutton, "Three Disputes and Three Objectives: China and the South China Sea," *Naval War College Review* (Autumn 2011): 42.

[5] Secretary of State Hillary Clinton emphasized freedom of navigation in the South China Sea as a "national interest" when speaking to the Association of Southeast Asian Nations (ASEAN) Regional Forum in 2010. Gordon Chang, "Hilary Clinton Changes America's China Policy," *Forbes*, July 28, 2010, http://www.forbes.com/2010/07/28/china-beijing-asia-hillary-clinton-opinions-columnists-gordon-g-chang.html.

[6] Dutton, "Three Disputes and Three Objectives," 44-45.

Figure 1. The Chinese claim is that the SCS belongs to the PRC and that notion is perhaps more potent today than it was 80 years ago.[7] However, the nature of claims the Chinese mean to exercise in the SCS (sovereign, historical, Economic Exclusion Zone (EEZ), and so forth) remains unclear.[8]

[7] Secretary of Defense, *Military and Security Developments Involving the People's Republic of China*, 15.

[8] Dutton, "Three Disputes and Three Objectives," 50.

Figure 1. China's "Historical Waters." The U-shaped Area Contained within the Dashes Represents Chinese-Claimed National Waters Dating to the 1930s. From[9]

[9] Dutton, "Three Disputes and Three Objectives," 46.

What has been surmised from Chinese actions is a policy of *jinhai fangyu*, meaning "Offshore Defense."[10] The Office of the Secretary of Defense (OSD) has defined PRC offshore defense as:

> [A]n overarching strategic concept that directs the PLA Navy to prepare for three essential missions including: keeping the enemy within limits and resisting invasion from the sea; protecting the nation's territorial sovereignty; and, safeguarding the motherland's unity and maritime rights.[11]

The extent to which China wishes to project this manner of defense is estimated to be the "near seas" which include the SCS.[12] It appears that official Chinese objectives for the SCS remain vague in order to curb international conflict. This provides the PRC extended room to elevate military might in the maritime region—potentially the focal point for the People's Liberation Army—Navy (PLA-N) aircraft carrier program.[13] All the while, disconnect between rhetoric and action is perhaps intended at inching out other maritime forces from the SCS. A firm example of this strategy was repeatedly on display in 2009

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[10] Secretary of Defense, *Military and Security Developments Involving the People's Republic of China,* 22.

[11] Ibid.

[12] Ibid., 22-23.

[13] Andrew S. Erickson, Abraham M. Denmark, and Gabriel Collins, "Beijing's 'Starter Carrier' and Future Steps: Alternatives and Implications," *Naval War College Review* (Winter 2012): 15-16.

when several Chinese fishing trawlers attempted on multiple occasions to collide with USNS Victorious and USNS Impeccable.[14]

Much has been made on potential economic boosts control of the natural resources of the SCS may bring to the PRC. However, as one begins to balance the cost of conducting war, to include commerce lost to enemies, the net yield does not appear reason enough for the PRC to risk hostile action.

China is however a country extending back millenniums, and it has led the world in many cultural regards. It is not beyond reason to estimate that the PRC, along with her present economic success, craves international prestige. Potentially the greatest way for the PRC world standings to rise is to exert opposition to the U.S. It is the assumption of this thesis that ultimately the maneuverings of the PRC in the SCS is intended to increase China's prestige relative to the U.S., and more specifically the USN.

Such a goal is achievable if the PLA-N successfully baits the U.S. Navy (USN) into firing first. By pulling the trigger and beginning the war, the U.S. forfeits moral high ground to the PRC. The outcome of such an ensuing battle is significant in terms of human life and financial outlay, but the social-political gains would already belong to the PRC.

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[14] Barbara Starr, "Chinese Boats Harassed US Ship, Officials Say," *CNN*, May 5, 2009, http://www.cnn.com/2009/WORLD/asiapcf/05/05/china.maritime.harassment/index.html?iref=allsearch.

b. United States SCS Perspective

The U.S., in addition to upholding maritime law in the SCS as previously discussed, has commitments to Eastern Asian allies to fulfill.[15] As the 2010 Quadrennial Defense Review (QDR) states:

> Anti-access strategies seek to deny outside countries the ability to project power into a region, thereby allowing aggression or other destabilizing actions to be conducted by the anti-access power. Without dominant U.S. capabilities to project power, the integrity of U.S. alliances and security partnerships could be called into question, reducing U.S. security and influence and increasing the possibility of conflict.[16]

As America's prime instrument for balancing power in the SCS, the U.S. Navy (USN) is presented with two key hurdles it must overcome: fiscal concerns driving the fleet to decreasing numbers, and an aversion to risking multi-billion dollar warships, namely aircraft carriers.[17]

At the close of fiscal year 2011, the U.S. surface fleet was comprised of 11 carriers (CVN),

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[15] "America's interests are inextricably linked to the integrity and resilience of the international system." Department of Defense, *Quadrennial Defense Review* (Washington, DC: Pentagon, February 2010): iv.

[16] Department of Defense, *Quadrennial Defense Review*, 31.

[17] "Little more than 13 years ago, with the public release of the U.S. Maritime Strategy, then-Secretary of the Navy John F. Lehman Jr. effectively argued that a 600-ship Navy was necessary to meet a U.S. national-security requirement for maritime superiority. Remarkably, the Navy today is on the threshold of falling below 300 ships the smallest fleet since 1931." John G. Kinney, and Gordon I. Peterson, "The U.S. Engagement Strategy: The Size of the Fleet Really Does Matter!" *Navy League of the United States*, July 28, 2010, http://www.navyleague.org/seapower/us_engagement_strategy.htm.

22 cruisers (CG), 61 destroyers (DDG), 26 frigates (FFG), 2 littoral combat ships (LCS), 14 minesweepers (MCM), and 31 amphibious ships.[18] Due to their lack of air radar and relatively small munitions, minesweepers are precluded from consideration for missile engagements with the PLA-N. Today's effective U.S. surface combatant force is 153 ships.

A max surge capability of two-thirds of all fleet forces is reasonable to assume due to persistent resupply, refitting, repair, and training demands. This results in approximately 100 surface combatants available for deployment at any given time. Of those 100, half will be dedicated to stability and security requirements of the Middle East and in home waters. Therefore, in this discussion it is approximated that the U.S. would likely have around 50 surface combatants available for engagements with the PRC. Composition of this fleet is estimated at: 3-4 carriers, 7 cruisers, 20 destroyers, 9 frigates, 1 littoral combat ship, and 10 amphibious ships.

One might say that the fleet is expanding based upon procurement plans for Zumwalt class (DDG 1000) destroyer, America class (LHA-R) amphibious ship, San Antonio class (LPD-17) amphibious ship, Arleigh Burke destoryer (DDG-51), and Freedom/Independence class Littoral Combat Ship (LCS). However, their production numbers will

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[18] United States Navy, "U.S. Navy Active Ship Force Levels 1886-Present," September, 2011, http://www.history.navy.mil/branches/org9-4.htm#2000.

roughly account for decommissioning rates in CGs,[19] FFGs, and amphibious ships.[20] Furthermore, Secretary of Defense Leon E. Panetta's testimony before the Senate Budget Committee regarding the $487B Department of Defense (DoD) budget cut declared ship production rates over the upcoming decade will fall below previous projections.[21]

It is also understood that in the unfortunate event of actual hostilities in the SCS, the overall commander may decide to favor Aegis vessels over amphibious ones, and LCS may comprise more of the current FFG numbers. This does not change the general points which are rooted in the relative number of hulls the PLA-N must deny access to, and the problems associated with the high cost to the U.S. for building and maintaining that fleet. To the later area

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[19] "[T]he Navy's planned fleet of more than 300 ships includes, among other things, a requirement for maintaining a force of 88 cruisers and destroyers. The 30-year (FY2011-FY2040) shipbuilding plan submitted by the Navy in February 2010, in conjunction with the FY2011 budget, does not contain enough destroyers to maintain a force of 88 cruisers and destroyers consistently over the long run." U.S. Library of Congress, Congressional Research Service, *Navy DDG-51 and DDG-1000 Destroyer Programs: Background and Issues for Congress*, by Ronald O'Rourke, CRS Report RL32109 (Washington, DC: office of Congressional Information and Publishing, April 19, 2011), 5.

[20] Secretary of Defense Leon E. Panetta testified before the Senate Budget Committee that projected DoD budget cuts include decommissioning of ships ahead of schedule such as cruisers, "The Navy, while it will maintain and protect some of our highest priority and most flexible ships, it will retire seven lower priority Navy cruisers that have been —that have not been upgraded with ballistic missile defense capability." *Senate Budget Committee: Opening Summary*, Washington, DC: Capitol Hill, February 28th, 2012 (statement of Leon E. Panetta, Secretary of Defense).

[21] Secretary of Defense Leon E. Panetta notified the Senate Budget Committee, "At the same time, we recognize that we've got to be able to look at our modernization needs and make decisions about those that can be delayed. This budget identifies about $75 billion in savings resulting from canceled or restructured programs... $13.1 billion by stretching investment in the procurement of ships." Ibid.

of concern, as $700M LCSs[22] replace the $64M FFGs[23] ($177M in 2012 dollars)[24] the U.S. in fact expends more money without appreciable gain in the number of surface assets.

The largest and most visible of all naval forces is the aircraft carrier whose ability to accomplish her mission in the face of harsh opposition is concerning. As a poignant article in the Autumn 2011 *Naval War College Review* declared:

> Currently, the 'airfield at sea' is almost the exclusive role for the large aircraft carrier, essentially fused with that of the 'geopolitical chess piece.' This [combined] role will continue to be highly useful into the future, so long as the intensity of defenses stays below a certain threshold. If either high-tech air or naval defenses proliferate, the number of areas and scenarios in which carriers can function in this role will decline. If this happens, the value of the carrier as a geopolitical chess piece will erode proportionately.[25]

The SCS, teeming with robust, high-tech naval defenses, precludes the U.S. from confidently employing her carriers as an airfield at sea in a time of hostility.

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22 Phillip Ewing, "LCS 2 Delays Trials After Engine Issue," *Military Times*, June 29, 2009, http://militarytimes.com/news/2009/06/navy_lcs2_delay_062909w/.

23 Global Security, "FFG-7 Oliver Hazard Perry-Class," July 7, 2011, http://libguides.nps.edu/content.php?pid=125051&sid=1076554.

24 The result was found using the Bureau of Labor Statistics cost inflation calculator with the average cost of the FFG program and the middle year of the program 1980. The calculator is found at: http://www.bls.gov/data/inflation_calculator.htm.

25 Robert C. Rubel, "The Future of Aircraft Carriers," *Naval War College Review*, Autumn 2011, http://www.usnwc.edu/getattachment/87bcd2ff-c7b6-4715-b2ed-05df6e416b3b/The-Future-of-Aircraft-Carriers.

Additionally, the role of the CVN as a political chess piece adds more significance to it should the PRC successfully "kill" one in the early stages of fighting. Such an attack would put a $10B hole in the USN ($17B including aircraft)[26] and fuel a massive wave of Chinese militaristic pride and further bolster their claim as a world power.

The loss of $17B worth of fighting machines, the ensuing international embarrassment, and the political victories for the PRC provides ample reason for American commanders to greatly consider not risking CVNs in a hostile SCS. In these austere times of budget reductions, retarding ship production rates, and an expanding PLA-N, the U.S. Navy must find creative ways to multiply its effectiveness in the SCS.

2. Anti-Access/Area Denial (A2AD): What the PRC is Expected to Bring to the Fight

The present era of warfare at sea is defined by missile technology.[27] In the missile era, the PRC casts a formidable shadow in the western Pacific with their current Air-to-Surface Missile (ASM) and Surface-to-Surface Missile (SSM) weapons systems. This technology has been pushed to the forefront of PRC interest in support of offshore defense.[28] To understand the SCS as a potential battle space

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[26] Hughes, "New Navy Fighting Machine," 32.

[27] "[M]issiles as the primary instruments of naval tactics." Hughes, *Fleet Tactics*, 3.

[28] Secretary of Defense, *Military and Security Developments Involving the People's Republic of China,* 22.

is to understand how PRC missiles shape that landscape. As the 2011 Annual Report to Congress on PRC military developments announces:

> China's A2AD focus appears oriented toward restricting or controlling access to the land, sea, and air spaces along China's periphery, including the western Pacific. For example, China's current and projected force structure improvements will provide the PLA with systems that can engage adversary surface ships up to 1,850 km [1,150 miles] from the PRC coast. These include: Anti-Ship Ballistic Missiles: Medium Range Ballistic Missiles (MRBMs) designed to target forces at sea, combined with overhead and over-the-horizon targeting systems to locate and track moving ships.[29]

a. PRC Missile Overview

The following PRC missile descriptions are provided in order to paint the SCS ASCM landscape at an unclassified level.

(1) Fu-Feng/JL-9 SS-N-22 "Sunburn" Anti-Ship Cruise Missile (ASCM). A 30 foot long SSM with a 100-155 mile range weighing around 9,900 pounds (lbs). Sunburn is said to travel between mach 2.1 and 2.5. It is guided by an Inertial Navigation System (INS) with command course updates in the mid-course phase, and has active/passive radar for the terminal phase. Most critically, Sunburn is designed to make supersonic evasive maneuvers during the terminal phase in order to defeat the self-defense missile and gun systems of the Aegis weapons system. The size of the missile (nearly three times the

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[29] Ibid., 29.

size of the U.S.' Tomahawk) in combination with its speed presents an incredible destructive force to its target on impact alone (in the scenario that an opponent ship neutralizes Sunburn's warhead and Sunburn still crashes into the target's hull). This missile system was purchased by the PRC in the late 1990s from Russia. The Sunburn is carried aboard destroyer class surface ships in the PLA-N.[30]

(2) Club/Caliber SS-N-27A "Sizzler" ASCM. SS-N-27A is a three stage SSM 27 feet in length, weighing around 4,200 lbs. Version A has INS with satellite mid-course update capability and active terminal radar. Flight speed ranges between mach 0.55 to 0.80 for phases one and two. SS-N-27A has a phase three which begins 12 to 40 miles from the target in which a terminal vehicle separates from the delivery bus, drops to an elevation between 15 and 30 feet above the sea surface, and proceeds towards the target at a speed of 2.2 Mach. The overall range of Sizzler A is approximately 135 miles and is deployable on surface and sub-surface assets in the PLA-N.[31]

(3) Club/Caliber SS-N-27B "Sizzler" ASCM. Version B differs from A by eliminating A's phase three (sprint phase towards the target) in exchange for increased range and improved warhead payload. It is suspected that an upgrade from INS to a Global Positioning System (GPS) is

[30] Jane's Strategic Weapons System, "Fu-Feng-1/JL-9 (SS-N-22 'Sunburn')," June 22, 2011, http://jsws.janes.com/public/jsws/index.hstml.

[31] Jane's Strategic Weapons System, "Club/Caliber (SS-N-27/-30 'Sizzler'/3M14/3M54/3M54M1/91R1/91R2)," August 24, 2011, http://jsws.janes.com/public/jsws/index.hstml.

included in version B as well. Sizzler B's range is an estimated 185 miles and deployable on surface and sub-surface assets in the PLA-N.[32]

(4) Club/Caliber-K SS-N-27 3M54E "Sizzler" Canister Missile System (CMS) ASCM. Developed in 2010, 4 Sizzler SSMs are packaged inside an International Organization for Standards (ISO) container box capable of launch from a merchant ship. It is unknown whether CMS contains version A or B of the SS-N-27.[33]

(5) DF-21D (CSS-5) ASCM. DF-21D is 35 feet in length, weighs 32,400 lbs, and is a two-stage SSM. Information Surveillance Reconnaissance (ISR) assets (satellites, submarines, fishing boats, et cetera) provide initial targeting information to DF-21D. A combination of INS and GPS give guidance to the missile during stage-one flight. The second-stage separates from the primary motor stage, and homes in on radar energy with an estimated Circular Error of Probability (CEP) of 65 feet. DF-21D is likely to be outfitted with a cluster flechette warhead designed to take out communications and radar equipment aboard ships as well as render carrier flight decks inoperable. Electromagnetic Pulse (EMP), High Explosive (HE), nuclear, and chemical warheads are potentially deployable on DF-21D as well. However, flechette offers the most politically attractive option for the ASCM purpose as it renders an opponent operational dead (soft-kill) with little chance to repair the carrier flight deck, while

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[32] Jane's Strategic Weapons System, "Sizzler."

[33] Ibid.

minimizing loss of life. DF-21D has an expected range of 960 miles and is predominantly employed from land based Transporter-Erector-Launcher (TEL) vehicles.[34] Figure 2 shows a standard profile of a DF-21D missile flight.[35]

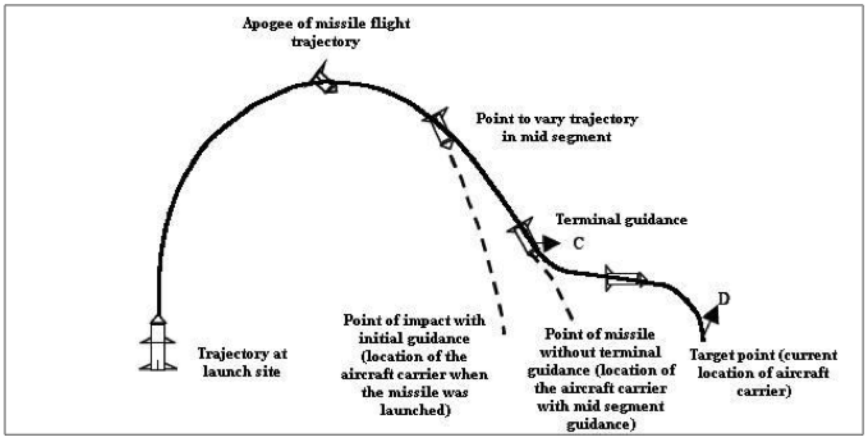

Figure 2. Profile for Land-Based ASCM Like DF-21D. From[36]

(6) CSS-N-4 "Sardine" (YJ-8/YJ-82/C-801) ASCM. The C-801 is a 19-ft long, 14-inch diameter, solid state rocket propelled SSM. Sardine has a flight speed of 0.9 Mach, and a range varying between 4.5 to 23 nm. The C-801 delivery vehicle weighs 187 lbs, but packs a 364 lbs semi-armor-piercing warhead that terminal homes on target using a mono-pulse I-band seeker. Upon launch, C-801 climbs to 165 ft, guided by INS, but descends to roughly 80 ft as it actively seeks its target. Upon acquiring a target,

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[34] Jane's Strategic Weapons System, "DF-21 (CSS-5)," June 21, 2011, http://jsws.janes.com/public/jsws/index.hstml.

[35] Secretary of Defense, *Military and Security Developments Involving the People's Republic of China*, 28.

[36] Ibid.

Sardine drops even further to approximately 20 ft above sea level on terminal flight.[37]

(7) CSS-N-8 "Saccade" (YJ-83/C-802/YJ-83A/C-802A) ASCM. The C-802 SSM is a turbojet propelled version of the C-801, extending the range of Saccade out to 97 nm.[38]

(8) C-803 "Ghader" ASCM. The C-803 SSM improved the range of the C-802 extending it out to 108 nm. It was developed by the Iranian Aerospace Organization in Tehran and is suspected to make its way on newer Houbei class missile boats.[39]

(9) C-602 (YJ-62) ASCM/Land Attack Missile. The C-602 is a 20-ft long, 21 inches in diameter, turbojet SSM. Traveling between 0.6 and 0.8 Mach, the YJ-62 has a max range of 151 nm and delivers a 660 lbs armor-piercing warhead. The C-602 cruises at 100 ft, but descends to about 25 ft above the sea surface on terminal phase. This SSM is initial guided by INS, and contains active, frequency-agile, mono-pulse terminal radar.[40]

b. PRC Fleet Overview

(1) Aircraft Carriers (CV). In 1998, the PRC purchased the unfinished aircraft carrier *Varyag* from the Ukranian government. In 2011 PLA-N conducted initial sea

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[37] Jane's Naval Weapons System, "CSS-N-4 'Sardine' (YJ-8/YJ-82/C-801); CSS-N-8 'Saccade' (YJ-83/C-802/YJ-83A/C-802A/Noor/Ghader); YJ-62/C-602," November 18, 2011, http://jnws.janes.com/public/jnws/index.hstml.

[38] Ibid.

[39] Ibid.

[40] Ibid.

trials of *Varyag* and returned her to dry dock for further refitting. DoD estimates that *Varyag* will enter full service as a ship only (no aircraft embarked) sometime in 2012. U.S. government analysts further believe "a number of additional years" are necessary for competency levels to rise in order to facilitate an embarked air wing full time.[41]

At full load *Varyag* is 65,000 tons, accommodating between 30-50 short-takeoff, vertical landing (STOVL) aircraft and helicopters. Presently, the PLA-N faces difficulties in obtaining arresting wire technology from Russia, which would enable conventional takeoff and landing (CTOL) of fixed winged aircraft.[42]

The latest Congressional Research Service (CRS) report on Chinese naval activity expects two to three additional carriers will be built indigenously. Chinese government sources and photographic evidence suggest that two carriers are presently under construction at Changxing Island Shipyard in Shanghai. Those photographs reveal an overall length around 850 ft, with a beam approximately 220 ft. Earliest commissioning date for these vessels is approximated at 2019-20.[43]

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[41] U.S. Library of Congress, Congressional Research Service, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by Ronald O'Rourke, CRS Report RL33153 (Washington, DC: Office of Congressional Information and Publishing, March 23, 2012): 17-18.

[42] Ibid., 18.

[43] Ibid., 19-20.

(2) Sovremenny Class Destroyer (DDGHM). PRC purchased four Sovremenny destroyers from Russia the first which entered PLA-N service in 1999, and the last in 2006.[44] A Sovremenny at full load is just over 8,000 tons and has an overall length of 511 ft, and a beam of 57 ft. Top speed is estimated at 32 knots (kts). At 14 kts a max range of 4,000 nm is expected. The compliment is a crew of 300 with an additional 25 officers. Each Sovremenny is armed with 8 SS-N-22 Sunburns.[45]

(3) Indigenous Destroyer Classes: Luda (Type 051), Luhu (Type 052), Luhai (051B), Luyang I (052B), Luyang II (052C), and Luzhou (051C).

Four Luda (Type051) destroyers, built between 1971 and 1991, remain in PLA-N service today. Type 051 displaces 3,800 tons at full load and has an overall length of 433 ft, and a 42 ft beam. Standard range is estimated at 3,000 nm at 18 kts, and carries a crew of 280 with 45 officers. Luda is outfitted with A-band air search radar, and E/F-band surface search radar as well. The Luda destroyer is also equipped with 16 C-802 missiles.[46]

Two Luhu (Type 052) destroyers, commissioned between 1994 and 1996, are in the PLA-N fleet presently. Luhu destroyers are 472 ft in length and have a 53 ft beam.

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[44] Congressional Research Service, *China Naval Modernization*, 21.

[45] Jane's Fighting Ships, "Sovremenny Class (Project 956E/956EM)," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml.

[46] Jane's Fighting Ships, "Luda (Type 051DT/051G/051G II) Class," January 3, 2012, http://jfs.janes.com/public/jfs/index.hstml.

At full load, the Luhu displaces 4,700 tons and carries 38 officers and 266 crewmembers. A standard range of 5,000 nm at a speed of 15 kts is estimated for this vessel. For radars, the Luhu has an A-band air search, G-band surface search, and an E/F-band air/surface search combination radar. Type 052 also carries 16 C-802 missiles.[47]

One Luhai (Type 051B) destroyer, the *Shenzhen* (DDGHM-167), remains in China's inventory. Her full displacement is 6,100 tons and is 505 ft long with a 53 ft beam. Her top speed is estimated at 29 kts. Luhai's standard range is reported at 4,500 nm at 14 kts. She is complimented with a crew of 42 officers and 250 men. *Shenzhen* has two dedicated air search radars covering A and G bands. She is also outfitted with an E/F-band radar used for combination surface/air search. As with her sister destroyers, she comes outfitted with 16 C-802 missiles.[48]

Two Luyang I (Type 052B) destroyers, both launched in 2002, are active in the PLA-N today. Luyang I is 7,100 tons at full load, stretching to 509 ft in length and 56 ft at the beam. Type 052B reaches an estimated top speed of 29 kts and has a nominal range of 4,500 nm at 15 kts. She is replete with 40 officers and 280 enlisted. Her air search radar operates in the E/F-bands, and her

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[47] Jane's Fighting Ships, "Luhu (Type 052A) Class," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml.

[48] Jane's Fighting Ships, "Luhai Class (Type 051B)," January 3, 2012, http://jfs.janes.com/public/jfs/index.hstml.

surface/air search radar covers the G-band. Luyang I destroyers are also armed with 16 C-802 missiles.[49]

Presently, two Luyang II (Type 052C) destroyers are in service and another two are under construction with expected commissioning in 2013-2014. 7,100 tons is Luyan II's full displacement. Her overall length is 509 ft, with a beam of 56 ft. The type 052C has a top speed of 29 kts, with a standard range of 4,500 nm at 15 kts. Aboard are 40 officers and 280 crewmembers.[50] According to a recent CRS report, "The Luyang II-class ships appear to feature a phased-array radar that is outwardly somewhat similar to the SPY-1 radar used in the U.S. made Aegis combat system."[51] Jane's Fighting Ships reports Luyang II possesses type 346 "Dragon Eye" phased array 3D air search/fire control radar covering A, G, and I bands. She is outfitted with only 8 C-602, and 8 HHQ-9 self-defense, surface-to-air missiles (SAM).[52]

Two Luzhou (Type 051C) destroyers are active in the Chinese Navy and were commissioned in 2006 and 2007. Type 051C has the same physical and manning characteristics of the Luhu, however the Luzhou is only equipped with 8 C-802 missiles vice 16.[53]

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[49] Jane's Fighting Ships, "Luyang I (Type 052B) Class," January 3, 2012, http://jfs.janes.com/public/jfs/index.hstml.

[50] Jane's Fighting Ships, "Luyang II (Type 052C) Class," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml.

[51] Congressional Research Service, *China Naval Modernization*, 22.

[52] Jane's Fighting Ships, "Luyang II."

[53] Jane's Fighting Ships, "Luzhou Class (Type 051C)," January 3, 2012, http://jfs.janes.com/public/jfs/index.hstml.

(4) Frigate Classes: Jiangwei I (Type 053 H2G), Jiangwei II (053H3), Jiangkai I (Type 054), and Jiangkai II (Type 054A).

Jiangwei I and Jiangwei II share the general dimensions of: 2,300 tons, 367 ft in length, with a 41 ft beam. Both classes have a top speed estimated at 27 kts, with a standard 4,000 nm range at 18 kts. Additionally, both classes have a total compliment of 170. Presently the PLA-N employs four Type 053H2Gs all commissioned in the early 1990s. Each Jiangwei I carries 6 C-802 missiles. However, 10 Type 053H3s are active today and were commissioned in the late 1990s to mid-2000s. The Jiangwei II frigates carry 8 C-802 missiles each.[54]

Slightly larger than the Jiangwei, the Jiangkai I and Jiangkai II have overall specifications of: 3,600 tons, 440 ft in length, and 53 ft in the beam. Each type has an estimated top speed of 27 kts, with a nominal range of 3,800 nm at 18 kts. The crew is estimated at 190 members. Only two Jiangkai I frigates are in the PLA-N inventory. They were commissioned in 2005 and 2006. Whereas, 10 Jiangkai II ships are fully in service and

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[54] Jane's Fighting Ships, "Jiangwei I (Type 053 H2G) Class," January 3, 2012, http://jfs.janes.com/public/jfs/index.hstml. And, Jane's Fighting Ships, "Jiangwei II (Type 053H3) Class," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml.

another six are under construction. The first Type 054A was commissioned in 2008. Both types of Jiangkai warships carry 8 C-802 missiles.[55]

(5) Corvette (Type 056). CRS reports several shipyards around the PRC are building the Type 056 corvettes. Procurement numbers and ship building schedules are unknown at this time.[56] However, Jane's estimates the PLA-N corvettes will displace between 1,000 to 1,800 tons and carry four C-802/803 missiles. It is anticipated that the Type 056 will replace the Houjian class (Type 037/2) fast-attack crafts (FAC).[57]

(6) Houbei (Type 022) FAC. Current estimates project that 100 Houbei FAC are to be built by the PRC with 83 already commissioned.[58] The Type 022 is a sleek and stealthy catamaran that can do 40 plus kts. A crew of 12 mans the 224 ton, 140 ft long by 40 ft wide missile boat. Each vessel carries 8 C-802 missiles packing the same firepower as the costlier and easier to spot PLA-N destroyers and frigates.[59] Houbei confirms that the PRC has a firm grasp on the below concept:

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[55] Jane's Fighting Ships, "Jiangkai I (Type 054)," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml. And, Jane's Fighting Ships, "Jiangkai II (Type 054A) Class," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml.

[56] Congressional Research Service, *China Naval Modernization*, 25.

[57] Jane's World Navies, "China," March 26, 2012, http://jwna.janes.com/public/jwna/index.hstml.

[58] Doug Crowder, "Storm Warnings?," *Proceedings Magazine* 138, no. 4 (April 2012) 19.

[59] Jane's Fighting Ships, "Houbei (Type 022) Class," March 2, 2012, http://jfs.janes.com/public/jfs/index.hstml.

[M]odern missiles have brought into question and sometimes overturned the principle of massing forces. A small naval vessel heavily armed with missiles in some tactical circumstances can take down enemy ships out of all proportion to its size.[60]

Figure 3. Houbei Class (Type 022) FAC. From[61]

(7) Amphibious Ships. PRC intends to build two classes of amphibious ships, both capable of operating helicopters, which in turn could potentially strike surface ships. One Yuzhao class (Type 071), a 17,000 ton amphibious vessel, was commissioned in 2008. Two additional Type 071 hulls are under construction or awaiting sea trials.[62]

Additionally, it is suspected that the PRC intends to construct a 20,000 ton Type 081 amphibious

60 Hughes, *Fleet Tactics*, 277.

61 Congressional Research Service, *China Naval Modernization*, 26.

62 Ibid., 27.

vessel. Such a large warship is estimated to have significant air capabilities along the lines of a helicopter carrier. The CRS report believes all together three Type 081 ships will be built.[63]

Table 1 summarizes the number of principle surface combatants in the PLA-N fleet both present and projected.

Number and Types of PLA-N Surface Combatants		
	Present	Projected
Aircraft Carrier	1	3
Sovremenny	4	4
Destroyer (Type 051/052)	13	15
Frigate (Type 053/054)	26	32
FAC (Type 022)	83	100
Amphibious (Type 071/081)	1	6
Total Surface Combatants	128	160

Table 1. Number and Types of PLA-N Surface Combatants

A summation of ASCM carried by PLA-N surface combatants is presented in Table 2.

PLA-N ASCM Fleet Totals by Ship Class		
	Present	Projected
Sovremenny	32	32
Destroyer (Type 051/052)	176	192
Frigate (Type 053/054)	200	248
FAC (Type 022)	664	800
Total ASCMs	1072	1272

Table 2. PLA-N ASCM Fleet Totals by Ship Class

Applying the two-thirds rule of ship availability to the PLA-N, the composition of their ships

[63] Congressional Research Service, *China Naval Modernization*, 28.

available for a potential SCS conflict (present day) is: 1 carrier, 2 Aegis type destroyers, 9 destroyers, 17 missile frigates, 1 amphibious vessel, and 55 missile FAC.

Table 3 shows the probable compositions of USN and PLA-N present day forces in the event of conflict in the SCS.

Probable Composition of USN & PLA-N Surface Combatants (Present Day)		
	USN	PLA-N
Aircraft Carrier w/Air Wing	3-4	0
Aircraft Carrier no Air Wing	0	1
Aegis Style Cruiser/Destroyer	27	2
Missile Destroyer/Frigate	0	26
Frigate/LCS no Missiles	10	0
Amphibious w/Helicopters	10	1
FAC w/Missiles	0	55
Total Surface Combatants	50-51	85

Table 3. Probable Composition of USN & PLA-N Surface Combatants (Present Day)

B. UNDERSTANDING NAVAL MISSILE WARFARE THROUGH MATHEMATICAL MODELING

Whether it is a few ships in a naval skirmish, or an entire fleet versus fleet engagement, the following model is applicable to all scales of naval missile warfare.

1. Salvo Model of Modern Missile Combat[64]

In preparing a cogent way to peel back the layers of PRC A2AD, it is important to understand the maxim of SUW:

[64] Title borrowed from: Hughes, *Fleet Tactics*, 268.

launch the first effective strike.[65] Captain Wayne P. Hughes, Jr., United States Navy (USN) (retired), in his seminal work *Fleet Tactics and Coastal Combat* examines the probable outcomes of two fleets engaged in missile warfare. Expanding upon the Lanchester Equation, Hughes develops the following equation modeling fleet missile combat:[66]

$$\Delta B = (\sigma_a \alpha A - b_3 B) \div (b_1)$$

Is the effect of fleet A's missile salvo on fleet B.

$$\Delta A = (\sigma_b \beta B - a_3 A) \div (a_1)$$

Is the effect of fleet B's missile salvo on fleet A.

In the above equations, a_1 and b_1 represent the "staying power" of that lettered fleet and is considered the number of missiles required to put a single ship out of action.[67] Characters α and β represent the "striking power" of each attacking fleet denoting the number of missiles that will hit opposition if there is no defense.[68] Symbols a_3 and b_3 represent "defensive power" which is the number of missiles a defender will successfully deflect or defend against when poised to receive attack.[69] Subsequently, "survivability" is derived from combining defensive power

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[65] Hughes writes, "It is wrong for the tactician merely to maintain an offensive frame of mind, thinking of nothing more than getting in the first attack. Naval forces must execute the first effective attack - the one after which the enemy can neither recover nor counterpunch successfully." *Fleet Tactics*, 309.

[66] Ibid., 268-273.

[67] Ibid., 268.

[68] Ibid.

[69] Ibid.

and staying power.[70] Additionally, scouting and range factors are represented by σ which scales from zero to one based upon a fleet's ability to not only detect/target the enemy but also find themselves within firing range.[71] In applying these equations Hughes derives Table 4 regarding first strike survivors.

	Initial Number of Missile Ships (A/B)				
	2/2	3/2	2/1	3/1	4/1
A attacks 1st	2/0	3/0	2/0	3/0	4/0
B attacks 1st	0/2	0/2	0/1	0/1	1/1
A and B strike together	0/0	0/0	0/0	0/0	1/0

Table 4. First Strike Survivors (A/B). From[72]

As the numbers demonstrate, *strike effectively first* is the supreme tenant of naval missile engagement. It is important to note especially the outcome of "B attacks 1st" when fleet "A" has a 4/1 advantage over fleet "B." The equation resolves to show a 1/1 force distribution whose subsequent outcomes are then determined by examining row "2/2." Again, from row "2/2" the ultimate victor is the fleet who can effectively strike first in the second volley. It is important to note that the 4/1 ratio is a tipping point where the smaller fleet faces great odds at *effectively* striking first because his numerical inferiority leaves too many ships with the ability to counterstrike in fleet "A."

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[70] Hughes, *Fleet Tactics*, 268.

[71] Ibid., 272-273.

[72] Ibid., 270.

When considering the U.S. Navy's role in the SCS, one realizes that in an effort to maintain moral superiority the American fleet will not "pull the trigger" and therefore is subject to the PRC fleet's advantage of firing first. This puts American forces behind the naval missile maxim. Knowing this, the key to success in the SCS is to render the PRC's first strike ineffective opening the door to an effective U.S. counterpunch.

To maintain a viable American fleet available for a returned missile volley, one realizes that the size of the U.S. forces in the SCS must meet or exceed four times that of the PLA-N. That, or scouting effectiveness of American ships must increase. Or, defensive power against PRC missiles must increase. Or most advantageous, a combination of all three previous factors, which in chorus provides the U.S. surface forces an effective opportunity to return fire. Additionally, by improving several facets of this model in favor of the U.S., the PRC must divide strategic thinking in order to overcome layers of American staying power.

C. THE NEW NAVY FIGHTING MACHINE

Captain Hughes specifically addresses how the USN can increase overall fleet numbers while maintaining present SCN budgets in his paper, "The New Navy Fighting Machine: A Study of the Connections Between Contemporary Policy, Strategy, Sea Power, Naval Operations, and Composition of the United States Fleet."[73] The following will highlight elements of his findings.

1. Historical Similarities and Rationale

In examining naval activities of capital ships in the Russo-Japanese war, and World War I, one can see the that the battleship was pushed farther away from operations in coastal waters as the threat of mines and submarines became more prolific.[74]

In a similar manner, if fighting were to break out in the SCS, the threat of DF-21 and the widespread employment of ASCM amongst PLA-N assets potentially push the carrier to operate at distances greater than 1,150 nm from the PRC coast.[75] Already the concerns over what the loss of a carrier means in terms of both finances and PRC pride have been discussed.[76] But to some extent, those principles are not entirely forgone when considering the American Aegis assets. It is understood the world over that an Aegis warship is the preeminent fighting vessel. The cost of that functionality comes at $2B per warship, arguably making her another prized trophy.[77]

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[73] Also referred to as NNFM study.

[74] Hughes, "New Navy Fighting Machine," 17.

[75] Secretary of Defense, *Military and Security Developments Involving the People's Republic of China*, 29.

[76] Covered in section I.A.1.b, "United States SCS Perspective."

[77] Congressional Research Service, *Navy DDG-51 and DDG-1000 Destroyer Programs*, 7.

In reviewing the Falkland War, one of the few examples of naval missile warfare, it is evident that even the most capable ships can be caught unaware by a missile strike. Such was the case with the HMS *Sheffield*, which was sunk on May 4, 1982, because she was not alert.[78] Believing a similar fate will not befall a U.S. DDG or CG is perhaps too optimistic—especially considering that the PRC has the element of surprise in firing the first shot. As Hughes soundly notes:

> A special concern for inshore warfare is a greater risk of catching a single ship napping because of the cluttered environment and the reduced battle space. I have yet to find a rationale for sending large, expensive, and highly capable warships into contested coastal waters unless they can take several hits and continue fighting without missing a beat after suffering a first attack by the enemy. It is better to fight fire with fire using expendable, missile-carrying aircraft or small surface craft. In fact, ever since the introduction of numerous torpedo boats, coastal submarines, and minefields... contested coastal waters have been taboo for capital ships and the nearly exclusive province of flotillas of small, swift, lethal fast-attack craft.[79]

It is staggering to consider the sheer number of Sunburn, Sizzler, DF-21, C-801/2/3, C-601, and various ASMs a U.S. Aegis ship must defend against in the SCS. Further consider the factor that doctrine normally requires

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[78] The sinking of *Sheffield* also highlights the successful employment of "soft kill" techniques by her sister ships HMS *Glasgow* and HMS *Coventry* that day in May, 1982 off the Falkland Islands. Sandy Woodward, *One Hundred Days* (Annapolis, MD: Naval Institute Press, 1992), 1-22.

[79] Hughes, *Fleet Tactics,* 290.

multiple shots at a single incoming missile. Historically speaking, maritime missile attacks at an alert target capable of defending itself, has a 32% success rate.[80] An American fleet engaged in a firefight in the SCS will face leakers, and there is a strong likelihood that several valuable surface vessels will be sent to the deep.

In the SCS scenario under consideration, the American fleet continues to build strategy based predominantly upon CVNs, CG/DDGS, FFG/LCS, and amphibious ships. However, as has been shown, the PLA-N is building intermediary levels of warships, dividing their mission areas into focused fields, while distributing their firepower.[81] All of this makes for neutralization of their offensive forces exceedingly difficult. It is the recommendation of this thesis that the USN in turn develops a more distributed force posture so as to improve the U.S. fleet's staying power and tactical prowess in the SCS.

Present-day Ship Construction Navy (SCN) is committed to replacing once technologically advanced, but now deteriorating U.S. warships with the latest, state of the art war machines on a general one-for-one basis.[82] However, the supreme investment of constructing the latest gadget filled vessel comes at the expense of growing the overall number of ships in the fleet. It is possible to see this procurement strategy as meticulously planned stagnation.

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[80] Hughes, *Fleet Tactics,* 276.

[81] See I.A.2.b "PRC Fleet Overview."

[82] Kinney, "U.S. Engagement Strategy," under "Little more than 13 years ago."

A research paper from the Naval Postgraduate School (NPS) titled the "The New Navy Fighting Machine" addresses how, without expanding the SCN budgets, the American fleet can increase both the number of ships and warfare areas. The driving ethos behind NNFM is summed as:

> Imagine now a strategical system... so that the navy will resemble a vast and efficient organism, all parts leagued together by common understanding and a common purpose; mutually dependent, mutually assisting, sympathetically obedient to the controlling mind that directs them toward 'the end in view.'

In this manner, the NNFM moves away from the self-contained, all in one concept that has pushed U.S. surface ships to the high extremes of technology and cost, which has made them so unaffordable to lose in battle. Instead, NNFM looks to restore the lessons found in PT boats, British MGB and MTB, light cruisers, corvettes, destroyer tenders, and so on—building affordable ships with focused purpose.[83]

2. Composition of the New Navy Fighting Machine

a. The NNFM Green Water Fleet

A U.S. fleet composition predicated upon the NNFM would offer significant assistance in the SCS. Chiefly, NNFM calls for the creation of a Green Water Theater Security and Coastal Combat fleet component at 10% of the Navy's SCN budgets.[84] The intent of the "Green Water Navy" is to beat back the clutter of defenses in the SCS opening

[83] Hughes, "New Navy Fighting Machine," 17.

[84] Ibid.

a battle-lane from which the Blue Water Navy can confidently operate inward from. Table 5 lists the elements of NNFM Green Water Fleet.[85]

NNFM Green Water Fleet	
Ship or Craft	Number of Units
Coastal Combatant	30
Offshore Patrol	160
Fleet Station Ship	12
Inshore Patrol	400
Gunfire Support	12
Fast Mine Warfare (MIW)	12
Anti Submarine Warfare (ASW) Ship	12
CVL (Green Water Fleet)	8
Coastal Combatant Tender	2
Total	648

Table 5. NNFM Green Water Fleet. From[86]

The primary missile shooter in the NNFM's Green Water Fleet is theorized to be a new coastal combatant. For the coastal combatant this thesis will adopt the Naval Postgraduate School (NPS) prototype *SeaLance*: a 500 ton, wave-piercing catamaran carrying four Harpoon SSMs, and 51 short-range dual-purpose SAMs/SSMs. Crew size of *SeaLance* is 12 with berthing aboard for 25 to facilitate SEALs, Marine Boat Unit, or staff movement. The design purpose of the *SeaLance* fleet is to go into harm's way to engage the enemy, accept losses, so as to better protect Blue Water assets and troop transports. Along these lines, *SeaLance* is expected to draw fire, take hits, and subsequently go down. The crews will not conduct extensive

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[85] Hughes, "New Navy Fighting Machine," 24.

[86] Ibid.

damage control (DC) efforts, and they will take to life rafts for collection by other USN forces.[87]

Offshore Patrol Craft are modeled after the U.S. Coast Guard (USCG) Sentinel class Fast Response Cutter (FRC). They will not be principal missile combatants, nor support helicopter operations. However, their main contributions will come in conducting maritime interdiction operations (MIO), and command, control, communications, computers, information, surveillance, and reconnaissance (C4ISR) in international sea-lanes and access points leading to the SCS.[88]

Small conventional carriers (CVL) will displace 25,000 to 30,000 tons and support an air wing of 20 F-35B STOVL fighter-attack aircraft. Additionally, unmanned aerial vehicles (UAVs) are potentially deployable on the CVL.[89]

The Gunfire Support ship is truly a single purpose vessel equipped with an Advanced Gun System (AGS), Evolved Sea Sparrow Missiles (ESSM), and countermine subsurface search capability. The displacement is based upon satisfactorily supporting the weapons and crew. Beyond that, if it is not associated with the AGS, ESSM, crew support, or safety of navigation it will not go on the Gunfire Support ship. Otherwise, this small warship is

[87] Hughes, "New Navy Fighting Machine," 19-20.

[88] Ibid., 24.

[89] Ibid., 23.

intended to transit to the firing line at emissions control (EMCON) alpha (no emissions), strike at land based targets, and scoot.[90]

b. *The NNFM Blue Water Fleet*

The U.S. fleet of today is predominantly geared for open ocean operations. Furthermore, it finds itself having more highly advanced missile ships (CG/DDG) in proportion to other open water assets such as simple destroyers, frigates, and corvettes. No other fleet in the world is so top heavy.[91] The sheer resources it takes to finance these advance missile ships drain the resources available for overall variations of the blue water warships the U.S. makes. The NNFM proposes a more balanced force structure composed of the ships in table 6 at 80%[92] of the current SCN budgets.

NNFM Blue Water Fleet	
Ship or Craft	Number of Units
CVN	6
CVL (Blue Water Fleet)	10
Land Attack	20
DDG/DDGX	30
Missile Frigates	90
Total	156

Table 6. NNFM Blue Water Fleet. From[93]

[90] Hughes, "New Navy Fighting Machine," 20-21.

[91] Ibid., 45.

[92] Ibid., 45-50.

[93] Ibid., 50.

The two proposed new ship designs in the NNFM Blue Water fleet are the Land Attack ships, and the Frigates. The NNFM Frigate lends a significant contribution to U.S. fleet efforts in the SCS.

Outfitted with eight long-range SSMs, the Frigate adds firepower in the corner of the USN offsetting a great deal of the offensive capability of the PLA-N Houbei FAC. Not acting simply as a missile boat, the NNFM Frigate is also equipped with an ASW suite, a helicopter or UAVs, and short-range hard/soft kill defenses.[94]

The Land Attack ship is a single purpose, austere, corvette sized vessel. This corvette is equipped with 50 Tomahawk-like missiles and can operate with battle groups or perhaps disperse from the surface action group (SAG) as prevailing tactics see fit. Such a design not only distributes the firepower amongst several hulls, it also has the multiplying effect of creating more targets that the PLA-N must address.[95]

3. Numbers Comparison between NNFM, Current U.S. Fleet, and PLA-N

The same two-thirds ship availability and operational commitments in the Middle East apply to the NNFM. However, a benefit of having ships with highly focused skill sets is their distinct application to problems. As NNFM carrier battle groups continue to rotate through the Persian Gulf, it is reasonable to assume they will not have need of the

[94] Hughes, "New Navy Fighting Machine," 47.

[95] Ibid., 48.

Green Water Fleet unless fighting is imminent. This facilitates Green Water Fleet resource dedication in the SCS. Therefore, the NNFM SCS contingent is comprised of: 20 *SeaLances*, 106 Offshore Patrol ships, 8 Gunfire Support ships, 8 ASW ships, 5 CVLs (Green Water), 2 CVNs, 3 CVLs (Blue Water), 7 Land Attack, 10 DDGs, and 30 missile Frigates. Table 7 shows the breakdown across today's USN fleet, today's PLA-N fleet, proposed NNFM fleet, and projected PLA-N fleet available for action in the SCS.

Probable Composition of USN, PLA-N, NNFM, & Projected PLA-N Surface Combatants				
	USN	PLA-N	NNFM	Projected PLA-N
CVN	3-4	0	2	0
CV/CVL	0	1	8	2
Aegis Style Cruiser/Destroyer	27	1	10	2
Missile Destroyer/Frigate	0	27	30	29
Combatants w/no SSM	10	0	129	0
Amphibious	10	1	8	4
FAC	0	55	20	67
Total Surface Combatants	50-51	85	207	104

Table 7. Probable Composition of USN, PLA-N, NNFM, and Projected PLA-N Surface Combatants

4. Conclusions

In strengthening treaties and by upholding international law, the U.S. has critical reason to police the SCS. Such actions might draw attack from the PRC who may view a U.S. presence as threatening. As Hughes masterfully derived, the pinnacle of modern naval warfare is delivering the first effective strike. U.S. fleet forces are likely restricted by Rules of Engagement (ROE) requiring new levels of resiliency against PLA-N offense.

When comparing U.S. surface navy numbers with the PLA-N, it is clear that American combatants are at a formidable disadvantage. The Hughes' missile equation reveals how increasing fleet numbers, increasing staying power, and improving scouting/targeting aid the American surface combatants greatly. The NNFM study articulates how fleet expansion is possible, even at present SCN budgeting, redoubling American preparedness in the SCS. Improving staying power, scouting, and targeting in the NNFM, further empowering the USN fleet to deliver that crucial counterpunch, are discussed in the following chapters.

II. COUNTER TARGETING IN THE NNFM

A. PRINCIPLES OF COUNTER-TARGETING (CT)

Captain Jeff E. Kline, USN (ret.), in his paper "Exploring Effects of Counter-Targeting in Naval Warfare" adapts the Hughes' missile equation to approximate the value of CT amongst surface combatants. He writes:

> To understand the effects of degrading the attacking force's scouting effectiveness, or targeting ability before launching an attacking missile, we degrade the parameter of σ of the attacking force. In our case, the scouting effectiveness parameter represents the attacking force's ability to target prior to missile launch, with $\sigma = 1$ being perfect targeting capability and $\sigma = 0$ meaning the attacking force lost all ability to target.[96]

To figure out what factor in targeting, σ, must be accounted for if a numerically inferior fleet were to achieve parity with the numerically superior fleet, Kline's model begins with fleet "A" numbering *m* times that of fleet "B":[97]

$$A = mB$$

From there, if the other factors of striking power and survivability are set as equal, it is determined that:[98]

$$\sigma_a = \sigma_b / m^2$$

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[96] Jeff E. Kline, "Exploring Effects of Counter-Targeting in Naval Warfare" (Naval Postgraduate School, 2012): 4.

[97] Ibid., 5.

[98] Ibid.

Or more directly put, fleet "B" must reduce the targeting ability of fleet "A" by a factor of the inverse square of the magnitude of fleet "A". To illustrate, if "A" were twice as numerous as "B", A = 2B, then *m* = 2 and $\sigma_a = \sigma_b / 2^2$ in order for "B" to reach parity with "A". In this example, for fleet "B" to achieve parity with fleet "A" it would have to reduce the targeting ability of "A", σ_a, to 1/4 the ability at which fleet "B" can target.[99]

Kline admits these calculations are theoretical.[100] However, to add some weight behind the mathematics, he employs a stochastic computer model to simulate surface combat between the two fleets with "A" set at twice the size of "B". In the model, to account for degradation to σ_a Kline increases the ability for "B" to go undetected which the computer considers "camouflage factor." As "B's" camouflage factor increased, "A's" targeting factor σ_a decreased proportionally. Figure 4 shows the results of running 30 mock battles between "A" and "B" with *m* = 2, and σ_a set at 0.25, 0.5, 0.75, 0.9, and 0.99 by means of "B's" camouflage factor.

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[99] Kline, "Effects of Counter-Targeting," 5.

[100] Ibid., 10.

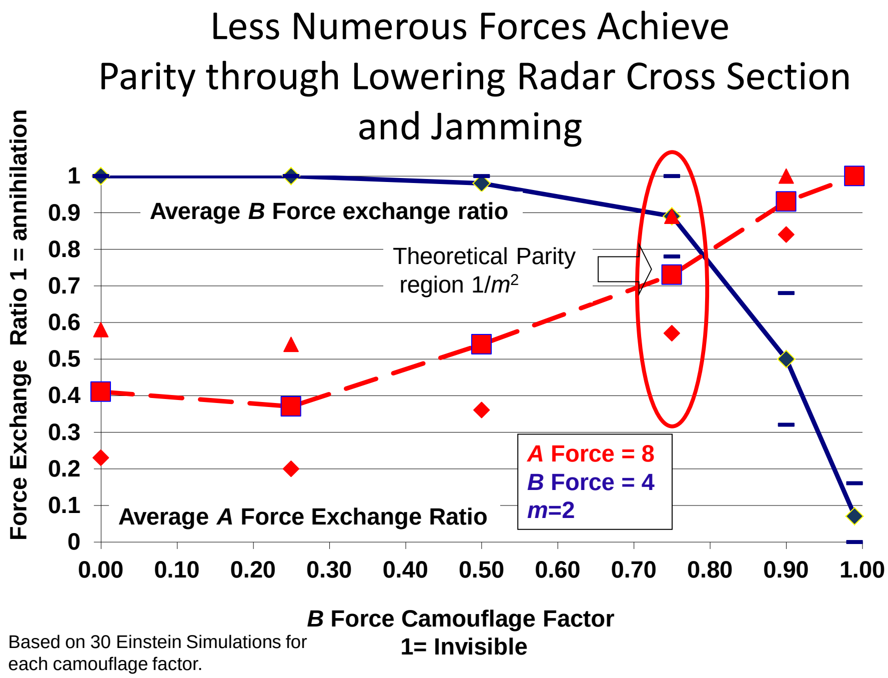

Figure 4. Less Numerous Force Achieves Parity by Countering the Larger Fleet's Targeting. From[101]

As shown in the modeling results, "B" begins to achieve parity at the theoretical σ_a of 0.25 seen at camouflage factor 0.75. Even though Kline titles his results, "Less Numerous Forces Achieve Parity through Lowering Radar Cross Section and Jamming" it is important to remember that any means of lowering an opponent's targeting factor, or increasing one's own scouting factor will achieve similar results.

A critical voice may offer that degrading an opponent fleet's targeting ability by factors as large as 75% may be

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[101] Kline, "Effects of Counter-Targeting," 8-9.

fiscally or feasibly impractical.[102] However, Kline's modeling demonstrates that disadvantages in fleet numbers can theoretically be made up via scouting, CT, or a combination of both. Furthermore, an attempt to regain parity, or improve past parity, need not be made in a single leap. CT comes in a variety of methods:

> [D]eception, electronic jamming, decoys, electromagnetic emission control, building ships with low radar cross section [RCS], reducing acoustic signatures, use of weather to mask ship movements and other information warfare techniques.[103]

It is urged by the authors that several avenues of CT and scouting come together in the combined effect of reducing the σ factor of the PLA-N fleet.

In specifically examining the PLA-N and the USN in the SCS, it is important to consider how the presently planned USN fleet and the NNFM fleet compare to the projected PLA-N. If the planned American fleet where to face the projected PLA-N, the Chinese would have a magnitude advantage *m* of 2.08.[104] Today's Navy would have to degrade

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[102] Kline also raises this point when he writes, "Degrading *A* Force targeting from 100% to 25% of *B's* targeting capability may, or may not be cost effective. Some sense of cost to achieve these effects is necessary and must be weighed against building more ships, or improving each ship's offensive, defensive, and staying power by the force advantage multiplier." "Effects of Counter-Targeting," 6.

[103] Ibid., 1.

[104] Magnitude factor *m* found using 104 available projected PLA-N forces versus 50 available USN forces as per I.C.3. 50 available USN is generous as it operates under the assumption that FFGs are outfitted with helicopters that can fire ASCMs thereby adding the FFG to the missile capable column. Additionally, current projections have US Aegis surface force numbers dwindling due to budgets cuts as previously discussed further inflating USN missile combatant numbers.

China's targeting to 23%[105] that of the USN's targeting capability to overcome inferior numbers.[106] The NNFM however would cut the magnitude edge of the projected PLA-N down to an *m* of 1.34 resulting in reduction of the PLA-N σ down to a more manageable 56% that of the American fleet.[107]

In addition, it is important to note that the NNFM would have 129 Patrol Craft intermixed with their primary combatant force of 78 missile platforms. To a PLA-N ASCM, these Patrol Craft are just as viable targets as other moderate displacement surface craft. The inclusion of Patrol Crafts in the NNFM fleet has the added advantage of doubling as CT decoys effectively reducing the σ of the PLA-N. No similar advantage exists in the modern American fleet.

This thesis will continue to address means by which CT could be accomplished.

B. USV AS ASCM CT ASSET

The root principles of naval missile warfare discussed so far have been strike effectively first, force ratio of missile shooters greatly effects the outcome, and CT/scouting adjustments can alter the effectiveness of an opposing fleet. The NNFM study articulates ways to increase

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105 With an *m* of 2.08, PLA-N σ for USN to achieve parity is $1/(2.08^2)$.

106 In the PLA-N/USN example, striking power, which the PLA-N has advantage in, and staying power, which the USN had advantage, are left to cancel out for the purposes of illustration.

107 Magnitude is calculated with projected PLA-N fleet of 104 ships and the NNFM SCS fleet of 78 ships as per I.3.C. Targeting factor is the result of $1/(1.34^2)$.

fleet missile shooter numbers. However, the first strike and CT factors are greatly enhanced with the inclusion of USVs in any version of the American fleet.

Picture the PLA-N and USN forces divided by 50 nm of open-ocean under heated tension in the SCS. The decision has been made on the PRC side to initiate hostilities and so the first wave of C-802s rocket off the decks of the PLA-N FACs, frigates, and destroyers. As the C-802s break the horizon and catch first glimpses of the American fleet, they lock onto the radar cross sections (RCS) their I-band, active seekers detect. Dropping down to 20 ft above the wave tops the first pulse makes a terminal run at their targets. One-half to two-thirds of the PLA-N missiles succumb to hard and soft kill U.S. defenses.[108] For the roughly one-third of the remaining missiles they strike home. The successful C-802s begin detonating their 364 lbs warheads in the ribs of the USN hulls. The unfortunate case for these missiles is that they homed in on the large number of USVs intermixed amongst the American naval assets. The USN missile shooters are left in force and ready to launch the first *effective* strike by means of a counterpunch.

What is stunning about the above scenario is it is by no means out of grasp. Wireless vehicle command technology is developed and continues refinement in a myriad of

[108] Analysis of 222 ASCMs fired between 1967 and 1992 against a range of shipping was conducted by John Schulte. From this data Hughes concluded that alerted warships were likely to successfully defend against two out of three incoming ASCMs. Whereas a warship caught unaware was likely to suffer two hits out of three incoming ASCMs. Hughes, *Fleet Tactics*, 275-276.

programs ranging from air, surfaces, and even subsurface vehicles.[109] The *Sea Fox* and the Common USV (CUSV) already demonstrate the ability to augment surface forces remotely and fiscally.[110]

The USV can adapt to a spectrum of uses, however it is highly encouraged that all fleet USVs include CT capability (adding to the number of valid surface targets an enemy missile will home on), and facilitate more robust fleet EMCON procedures.

In examining both the PLA-N fleet of today and their projected fleet, the predominant SSM is by far the C-802. Understanding that the Sovremenny class is the only PLA-N surface vessel known to carry the SS-N-22 Sunburn, all other potential surface opponents fire the Saccade.[111] This makes the PLA-N present day SSM inventory 32 Sunburns, and 1,040 C-802 Saccades.[112] The projected PLA-N forces are similarly Saccade centric with 32 Sunburns, and 1,240 C-802s anticipated.[113]

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[109] Department of the Navy, "The Navy Unmanned Surface Vehicle (USV) Master Plan" (Pentagon: Washington, D.C., 2007): 1-5.

[110] CUSV participated in Trident Warrior off the coast of San Diego, CA in 2011 successfully demonstrating autonomous and man-in-the-loop vehicle control. 2012 Trident Warrior expects CUSV to conduct mine hunting and clearance, SUW, C4ISR, and communications relay. Textron Systems Corporation, "Textron Systems Successfully Demonstrates Its Second Common Unmanned Surface Vessel," *Market Watch*, April 17, 2012, http://www.marketwatch.com/story/textron-systems-successfully-demonstrates-its-second-common-unmanned-surface-vessel-2012-04-17.

[111] It is noted that the Luyang II destroyers fire the C-602 SSMs. However, the guidance systems in the "C" series of SSMs operate on the same principles.

[112] Numbers are based on platform and their SSM load out as per I.A.2.b.

[113] Numbers are based on platform and their SSM load out as per I.A.2.b.

Again, it is known that the PRC has tactical air (TacAir) assets, and a potent submarine force that deliver some of the more dangerous Russian derivative missiles. It is the purview of this thesis to examine ways in which the USN surface assets regain dominance over a threatening PLA-N surface force, and understands that American subsurface and air components are expected to similarly find dominance in their domains as well.

Employing a combination of INS and an active I-band seeker, the C-802 relies upon reflected radar energy at a predetermined range from their launch point in targeting. This method of targeting is not highly discriminatory as exemplified by the C-802 that slammed into a Cambodian flagged freighter intended instead for Israeli Naval Ship *Spear* in July of 2006.[114]

Knowing that the RCS is the critical factor in countering the C-802 missile, one can see in figure 5 that general RCS profiles of ships ranging from several hundred tons to 35,000 tons overlap in the 10 meters (m) squared range. This wide area of overlap provides a tactical window in which USVs can offer Saccade cover for American warships.

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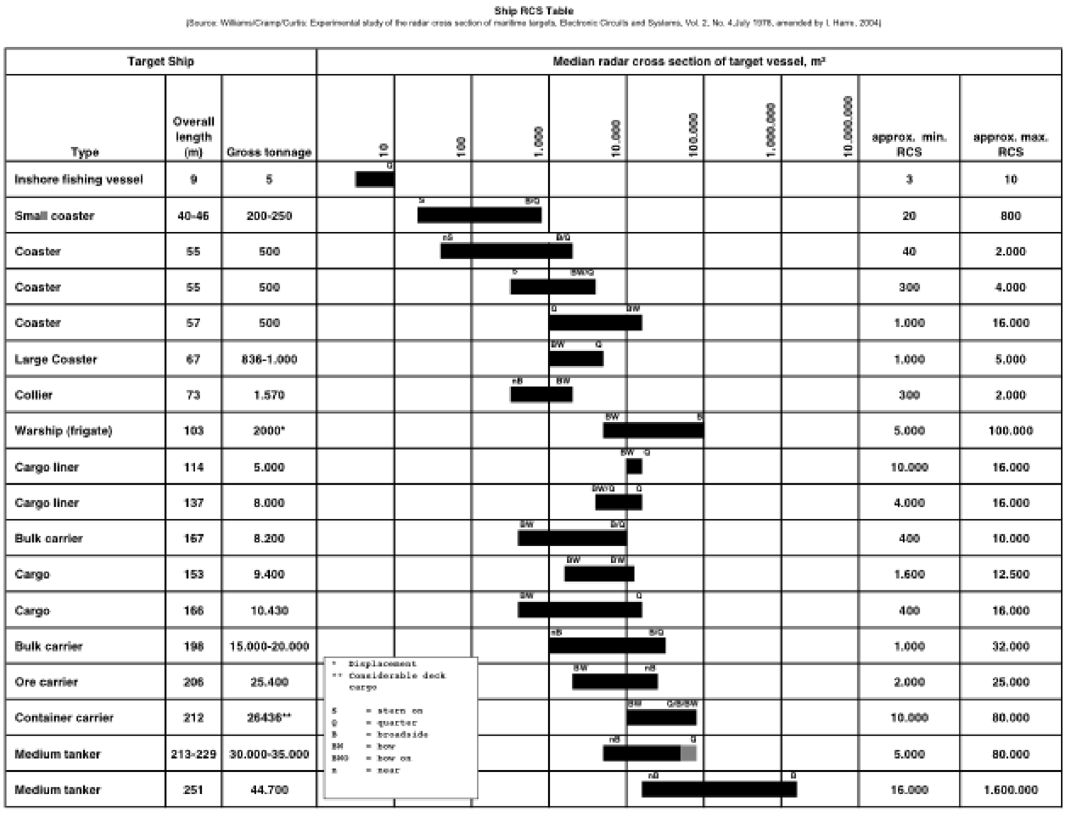
[114] Amos Harel Haaretz staff, "Soldier Killed, 3 Missing after Navy Vessel Hit off Beirut Coast," *Amos Harel Haaretz Paper*, July 15, 2006, http://www.haaretz.com/news/soldier-killed-3-missing-after-navy-vessel-hit-off-beirut-coast-1.193112.



Ship RCS Table

(Source: Williams/Cramp/Curtis: Experimental study of the radar cross section of maritime targets, Electronic Circuits and Systems, Vol. 2, No. 4 July 1978, amended by I. Harre, 2004)

Type	Overall length (m)	Gross tonnage	approx. min. RCS	approx. max. RCS
Inshore fishing vessel	9	5	3	10
Small coaster	40-46	200-250	20	800
Coaster	55	500	40	2.000
Coaster	55	500	300	4.000
Coaster	57	500	1.000	16.000
Large Coaster	67	836-1.000	1.000	5.000
Collier	73	1.570	300	2.000
Warship (frigate)	103	2000*	5.000	100.000
Cargo liner	114	5.000	10.000	16.000
Cargo liner	137	8.000	4.000	16.000
Bulk carrier	167	8.200	400	10.000
Cargo	153	9.400	1.600	12.500
Cargo	166	10.430	400	16.000
Bulk carrier	198	15.000-20.000	1.000	32.000
Ore carrier	206	25.400	2.000	25.000
Container carrier	212	26436**	10.000	80.000
Medium tanker	213-229	30.000-35.000	5.000	80.000
Medium tanker	251	44.700	16.000	1.600.000

Figure 5. General RCS Profiles of Ships by Tonnage. From[115]

Exploiting RCS is achievable by two general methods. The first method is to adjust the RCS of a USV so it looks larger and therefore more likely to attract the incoming ASCM. The second method is for the covered warship to minimize its profile by means of maneuvering relative to inbound ASCM thereby minimizing her own RCS.

In the first method, a USV can artificially have her RCS increased so as to best adjust to the ships she is providing CT for. From design, a fleet USV ought to have an

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[115] P. D. L. Williams, H. D. Cramp, and Kay Curtis, "Experimental Study of the Radar Cross-Section of Maritime Targets," *IEEE: Electronic Circuits and Systems* 2, no. 4 (April 1978): 129.

innate RCS similar to the smaller surface combatants expected in USN inventory. In the NNFM this would be the *SeaLance* and Patrol Craft. In the current USN fleet it would be the LCS. From this elemental RCS profile, adding radar reflectivity would be scaled in accordance to the SAG composition. For example, if a SAG contained Aegis assets, the CT USV is adjusted so as to have a similar RCS. However, if the SAG is composed of LCS, or *SeaLance*, then the USV radar reflectivity is not adjusted.

Increasing the RCS of objects is a sound principle well known to the mariner who relies upon radar reflective shapes located on navigational buoys. Affixing similar objects to a USV to range in RCS profiles is therefore no technological stretch and is achievable even by crews at sea affixing prescribed radar reflectors in a predetermined configuration. This is especially attractive in the sense that much effort has been spent reducing the RCS of warships, which is exceedingly difficult and costly. Here, one wants to do the implicitly simple: allow the radio energy to return to the ASCM seeker.

Tactically speaking, the SAG can create a CT USV buffer (see Figure 6). This tactic identifies the high value unit (HVU) and establishes an RCS on the USV similar to the HVU.[116] The screen commander then establishes the buffer by placing the USVs in the surface screen down the

[116] The authors maintain that the CVN is at risk in the SCS if it is within roughly 1,000 nm from PRC coast due to DF-21 ASCM threat. It is expected that engagements between PLA-N and USN fleets will be carried by other surface assets likely making Aegis ships, Amphibious vessels, and tankers HVUs. These likely HVUs fall within the exploitable 10 m^2 RCS range.

threat vector from the HVU. The intention of placing the USVs in this fashion is for the wave of ASCMs to lock onto the first set of targets encountered in the surface group's vicinity thereby leaving a fewer number of ASCMs available to transit further onto the SAG.

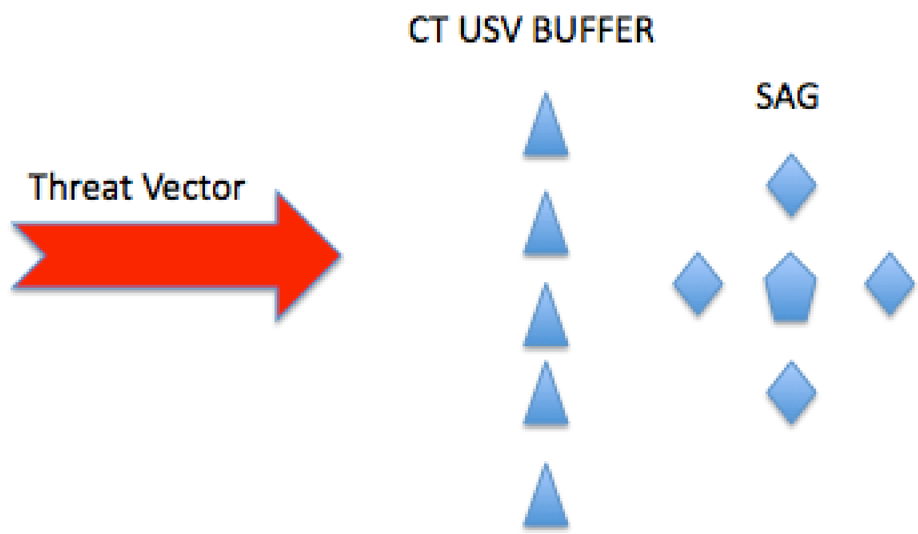

Figure 6. CT USV Buffer Tactic

The buffer tactic is seen in today's SUW forces with the unfavorable tradeoff of sacrificing both offensive power and lives for an increase in defensive power of the HVU. A flotilla of CT USVs offers a true "missile sponge"[117] in the SAG screen allowing the commander to maximize firepower retention while raising the defensive power of all combatants in the screen.

Once it is determined that ASCMs are inbound on the SAG, the missile combatants should further complicate the

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[117] Term applied to surface assets intentionally placed between ASCM threat and HVU.

opponent's missile targeting by minimizing their own RCS profiles (see Figure 7). For example, if the port or starboard quarter is the least radar reflective profile, the SAG should proceed in a direction relative to the inbound missiles to which the ASCM seekers are presented the quarter aspects of the SAG combatants. This leaves the CT USV buffers exposed and attractive to the ASCMs.

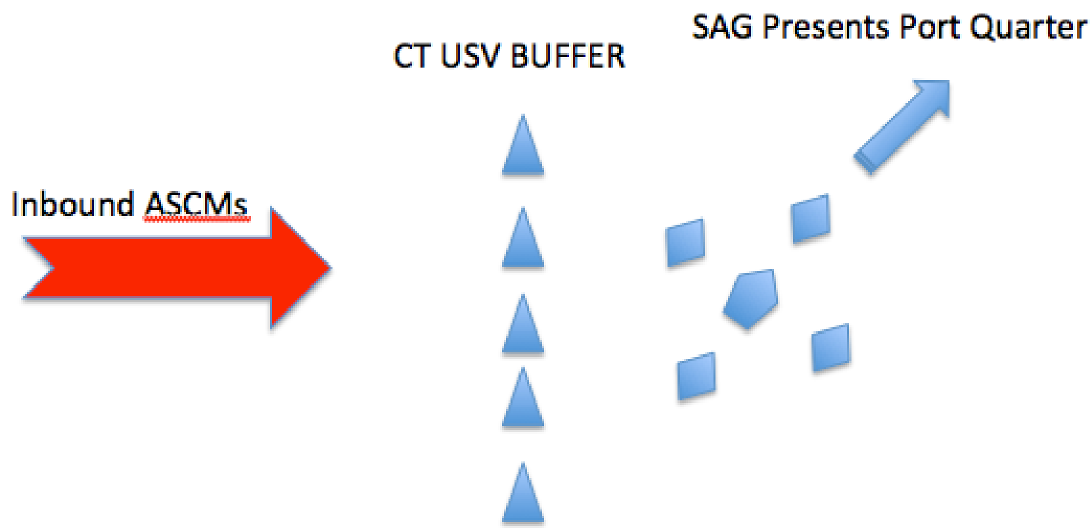

Figure 7. CT USV Buffer Tactic with SAG Minimizing RCS Profile

Incorporating a ship-counter on the ASCM potentially defeats the buffer tactic. A ship-counter would simply direct the ASCM to home in on say the third target it deems valid. This would cause an increased number of inbound ASCMs to bypass buffers, picket lines, or outer rings of the SAG screen. Inverting the buffer tactic by placing the HVU closest to the threat can have serious subsurface warfare ramifications. Instead, even disbursement of USVs across the surface screen would negate further ASCM developments aimed at exploiting SAG geometry as shown in Figure 8.

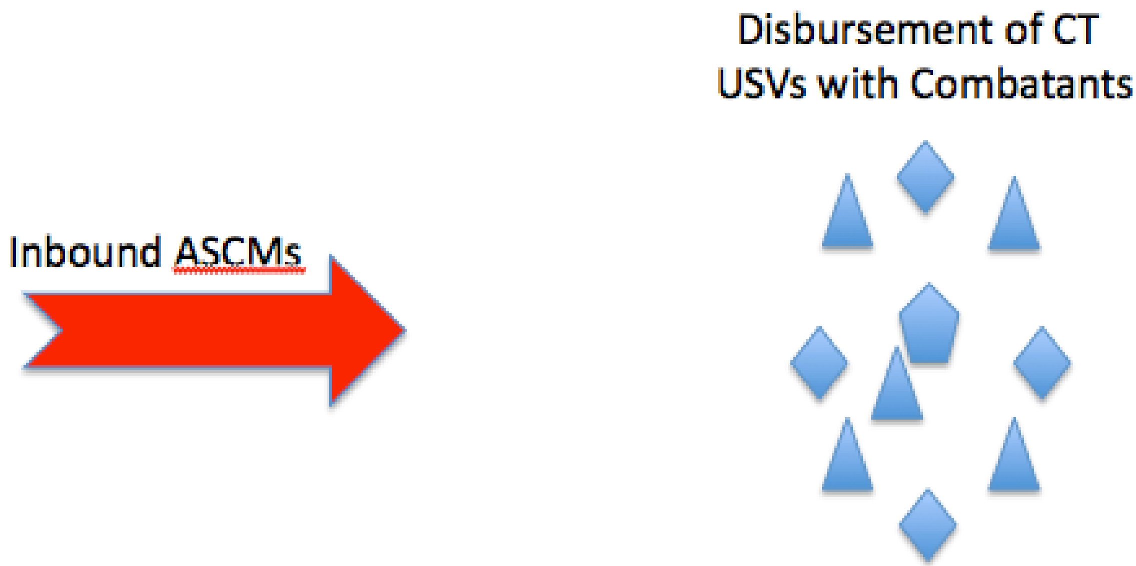

Figure 8. CT USV Disbursement Amongst Combatants Tactic

Should the PRC develop ship-counter technology and implement them on their ASCMs, their reliance on RCS based targeting is tremendously confounded by the disbursed presence of USVs. Also, even disbursement presents nearly identical SAG screen geometry no matter the approach vector of the ASCM. This removes any advantage the PLA-N might seek in providing waypoints to ASCMs en route to American surface groups intending to bypass CT measures.

It is hard to predict what exactness future technologies might bring to missile seekers. It is however known that the PLA-N SSM ASCM inventory is at least 97%[118] C-802. The "C" series of missiles, with targeting technology founded upon radar principles of the 1980s, is susceptible to CT. Should every missile combatant in the SAG have a counterpart USV, reasoning has it that half of every PLA-N RCS based ASCM will go after the USV decoy. CT USVs potentially cut the PLA-N surface force striking power in half.

A further implication of employing USVs for CT is forcing the PRC to develop new and complicated methods of targeting. The principle paths for PRC development in these areas are refined RCS homing so as to keep the "C" missiles viable, to which the U.S. can further refine counter RCS tactics making this route a hard game for the PRC to pursue. The other clear route for PRC targeting is to develop anti-radiation missile (ARM) seekers. Later in this chapter the USV as an EMCON and CT ARM platform will be examined.

As it stands, the implications of CT USV have not been addressed by overarching USN USV vision. According to "The Navy Unmanned Surface Vehicle (USV) Master Plan" a fleet USV is actively under development that will provide mine countermeasures (MCM), anti-submarine warfare (ASW), surface warfare (SUW), special operations forces (SOF) support, electronic warfare (EW), and maritime interdiction

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[118] Today's estimated PLA-N SCS fighting force has fewer Saccades by ratio than the projected fleet. Percentage was computed with figures found in chapter I of 1,040 "C" series missiles divided by 1,072 total PLA-N fleet ASCMs.

operations (MIO).[119] Of course USVs with such a wide spectrum of warfare missions could potentially assist the maritime commander greatly. However, as America's focus draws upon the SCS it is important that the crucial elements needed for the USN fleet to gain tactical advantage be identified and delivered. No CT USV role is articulated under the USV master plan. As discussed above, there is clearly a need for CT amongst SUW forces in the missile environment of the SCS and any USV that is delivered to the American fleet must fundamentally fulfill this mission above all others.

C. USV AS SURFACE EMISSIONS ASSET

1. Example of Low Probability Detection Interception (LPDI) DoD Technology

The U.S. Air Force (USAF) Fast Airborne Laser Communications Optical Node (FALCON) laser network research program has yielded notable success in turning optics based data paths into viable, high bandwidth lines of communication. A white paper titled "Observations of Atmospheric Effects for FALCON laser Communication System Flight Test" summarizes the breakthrough 2010 experiment.

In this experiment a combination of DC-3 and DHC-6 airplanes flew at unpublished altitudes banking, turning, changing elevation, and altering distances from each other all while maintaining an optical laser data path (see Figure 9).[120] Even separated at 80 miles (mi), FALCON laser

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[119] Department of the Navy, "Navy USV Master Plan," iv-v.

[120] Beverly Thompson, "FALCON, Fast, Far, and First," May 7, 2010, http://www.wpafb.af.mil/news/story.asp?id=123203630.

communications maintained a 2.5 gigabit-per-second (Gbps) link for several hours. At the time of the experiment, two operational FALCON transceivers had been made at a data rate of 2.5 and 10 Gbps, respectively. The FALCON project team expects as more transceivers are produced at the higher data rates that 10 Gbps of throughput are achievable.[121]

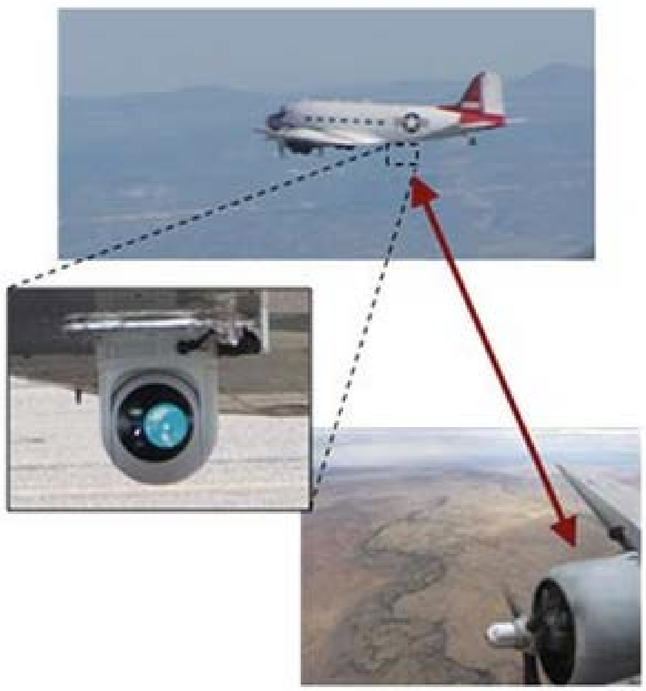

Figure 9. FALCON Laser Node Affixed to DC-3 Aircraft. From[122]

The idea of using lasers to create optical, high rate, LPDI networks has existed for over 30 years.[123] The primary

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[121] Air Force Research Laboratory Wright-Patterson Air Force Base, *Observations of Atmospheric Effects for FALCON Laser Communication System Flight Test* (Wright-Patterson Air Force Base, OH: 2010): 2.

[122] Thompson, "FALCON."

[123] Air Force Research Laboratory, *FALCON Laser*, 1.

factor preventing laser optic networks has been atmospheric scintillation characterized as beam movement and beam blur.[124]

The laser produced by the FALCON transceivers overcome atmospheric blur by incorporating a collimator and axicom to produce a Bessel beam. A Bessel beam is non-diffractive, and self-healing. Bit error correction on the receiver side of the transceiver further reduces the effects of optical blur.[125]

To overcome beam movement, the FALCON team created a dynamic optical tracking system based upon a Fast Steering Mirror (FSM). A wide field of view beam keeps the FSM in sight with the corresponding FALCON transceiver, while a narrow beam is used for actual data transmission. Real time analysis of errors from the data signal produces an aggregate atmospheric wave-front tilt used to correct the FSM angle in order to center on the beam axis. In this manner, FALCON has successfully managed the complications of optical transmission in a heterogeneous atmosphere.[126]

Even though FALCON laser paths have successfully demonstrated ground-to-ground, air-to-ground, and air-to-air links, two factors arise in applying this technology to naval use. Firstly, offsetting the pitch and roll of a ship at sea in order to provide a stable platform is unproven and potentially disruptive to the optical pathway.

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[124] Air Force Research Laboratory, *FALCON Laser*, 2-5.

[125] Ibid.

[126] Ibid.

Secondly, an encasement for FALCON transceivers that do not foul under maritime conditions (e.g., salt buildup) are not yet developed. Despite these practical and valid concerns regarding naval application of optical data paths, it is encouraging to note the conclusions of the FALCON white paper:

> [The successful demonstration] shows that laser communication is a viable communication option for operational consideration. The operational utility of systems such as FALCON must now be investigated as the performance of these systems continue to improve.[127]

Again, this thesis points to FALCON as an example of a highly capable and developing LPDI communications path. As will be seen, the edge gained from LPDI paths should encourage USN involvement in leveraging such a powerful tool for maritime application.

2. USVs at EMCON

Knowing that the USV can provide CT cover from RCS seeker based ASCMs for USN surface combatants, it is time to exploit the EMCON potentials of the USV.

Triangulating a SAG's location by means of detecting their electro-magnetic (EM) emissions is a well understood technique of modern warfare. A traditional counter, known as EMCON alpha, is for the SAG commander to order ships in company to stop emitting EM energy. The EMCON alpha tactic

[127] Air Force Research Laboratory, *FALCON Laser*, 10.

will continue to be a vital card in the SAG commander's hand, however there are some modifications that might prove useful.

Having USVs outfitted with legacy radio frequency (RF) communications gear[128] and LPDI "tethers" (linking warship and USV without emitting EM energy) the SAG commander can spoof his surface group's location. To achieve the spoof, the navigational equipment and legacy communications pathways aboard the USVs serve as the eyes and ears for the transiting SAG. All information is then relayed from the USV to the warship it is companioning via the tether (see Figure 10).[129] It is intended that an opponent receive the USVs' EM emissions thereby tracking the group by this EW means.

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[128] USV Master Plan points towards the vastly developed Unmanned Arial Vehicle (UAV) field of communications as an example of how RF communications pathways are viable on even vehicles smaller than what is intended for a USV. The paper therefore concludes that there will be an ease of transitioning RF gear onto USVs. Department of the Navy, "USV Master Plan," 32-37.

[129] Although the most advantageous tether would be an LPDI pathway such as FALCON, a wired "umbilical" system is plausible such as the Avenger class mine counter measures umbilical cabling connecting to the AN/SLQ-48 mine neutralization subsurface vehicle.

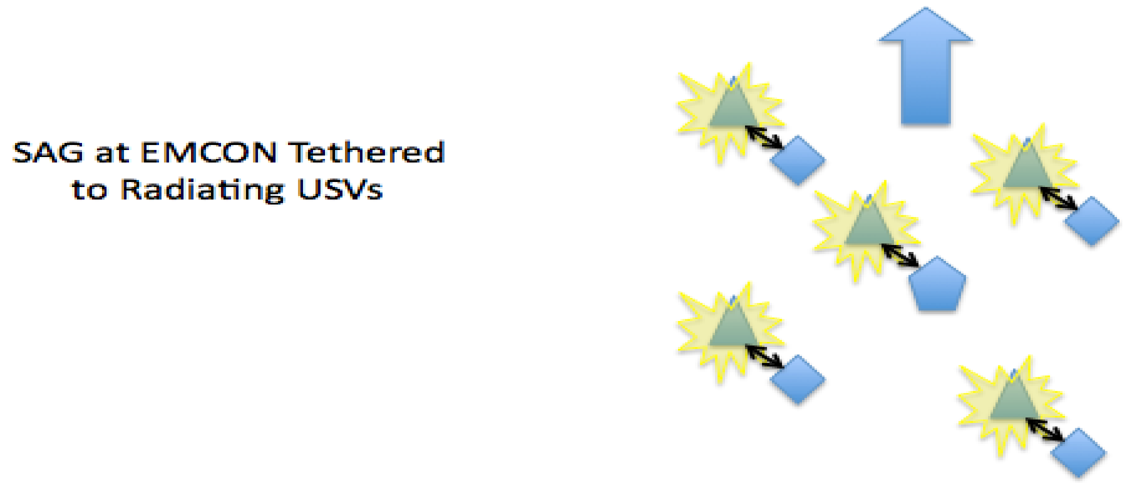

Figure 10. SAG at EMCON Tethered to Radiating USVs

Subsequently, the SAG commander closes to just outside SSM range of the enemy surface group. Ordering his warships to oblique, the commander has the USVs sever ties with the SAG yet continue radiating along their previous path. The warships angle off from their electronically loud counterparts at EMCON alpha in order to close their opponent undetected as shown in Figure 11.

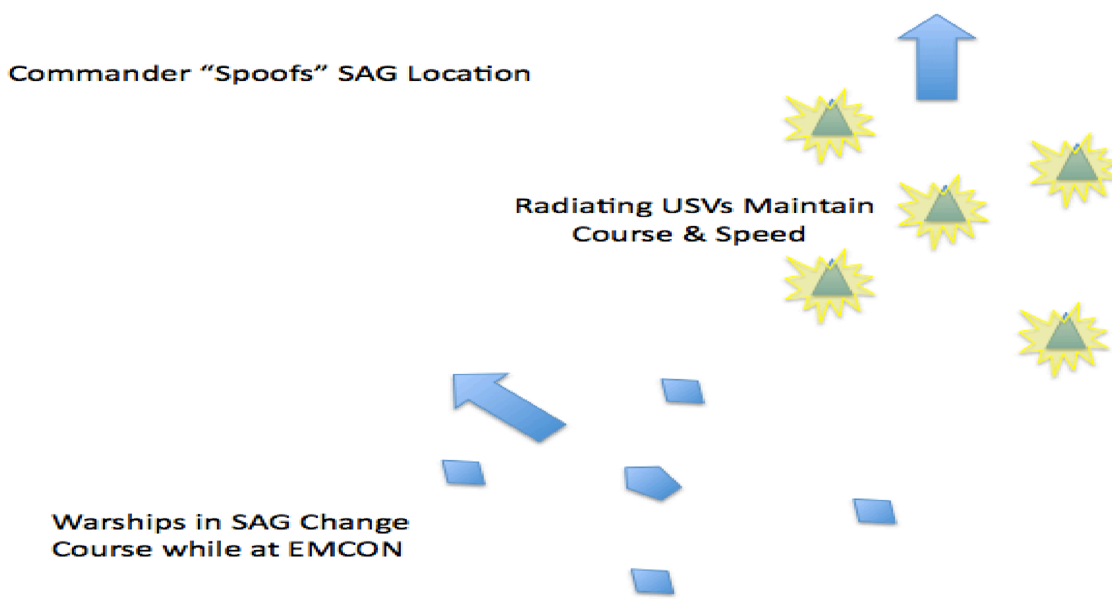

Figure 11. Spoof Tactic Using USVs and EMCON Alpha

The deception should offer the commander several advantages from which to fire his missile salvo. Firstly, surprise allows the commander to choose the most opportune time to launch his attack. Secondly, opponent EW and screen geometry effectiveness is reduced due to the false threat vector presented by the USVs. Of course, spoofing the SAG's location has other applications beyond targeting an enemy with SSMs, but the illustration and advantages serve to demonstrate the incredible tactical ability that the USV can serve in the SUW EW realm.

As mentioned previously, the PRC could potentially pursue surface-to-surface ARMs making the USV an invaluable CT mechanism. A SAG proceeding in the SCS under an EMCON condition as pictured in Figure 10 (USVs acting as the eyes and ears for the tethered warship) deny ARMs the ability to target American combatants. Instead, the PLA-N ARMs would home on the USVs. A sound tactic validated by today's strategy of launching helicopters from EMCON alpha warships in order to draw ARM fire at the aircraft vice the ship.

By employing USVs, the American fleet can drastically alter the EW landscape in the SCS and hedge against ARMs. Furthermore, it would reduce risk to aircrews, allowing the helicopter asset to remain in service to the commander for longer. Additionally, warships are afforded safety from ARMs at EMCON alpha without forgoing the ability to conduct EM based communications and navigation.

D. NAVAL OBSCURANTS

Further complicating targeting for the PLA-N ASCM is achievable in marrying World War II surface battle group smoke screen tactics to modern age radar obscurants. Modern age obscurants work on the same principle as smoke screens did in the 1940s—obstructing the vision of the targeting system thereby increasing the likelihood of an enemy miss.

LCDR Brett Morash, USN, in his research paper, "Naval Obscuration" for the Naval War College, investigated the adaptation of the U.S. Army's M56E1 Coyote wide area obscurant generator for naval application. The M56E1 multi-spectral smoke generator produces a "smoke" that absorbs or scatters visible, infra-red (IR), and millimeter wave (MMW) EM energy.[130] An advantage in obscuring EM emissions is that the radar energy makes two passes through the obscurant cloud (once from the missile emitter, and once reflecting back from the target) increasing the CT effectiveness.[131] His research also reveals the combined effect of the obscurant on the ASCM seeker:

> [T]o reduce RCS below the minimum signal required for targeting by an ASCM seeker head, with the reflective obscurant causing an increase in radar automatic gain control [AGC] thereby causing ASCM seeker processor saturation.[132]

Additionally, the advances in MMW obscuration for the Coyote system are significantly more effective than the Super Rapid Blooming Offboard Chaff (SRBOC) presently aboard U.S. warships.[133]

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[130] Brett Morash, "Naval Obscuration" (Naval War College, 2006): 1.

[131] Ibid., 2.

[132] Ibid., 5.

[133] Ibid.

In discussing the methods of defeating RCS based missiles, *Naval Obscuration* studied the theoretical effects of M56E1's smoke on the ARGS-54 seeker found in the more potent SS-N-27 ASCMs. ARGS-54 employs AGC, and a system to prevent target overload known as constant false alarm rate (CFAR). The Coyote's smoke is believed to significantly delay acquisition of ships by the ARGS-54, and quite possibly prevent any targeting whatsoever. Even if the EM absorbent smoke fails to completely deny the ARGS-54 from identifying a ship, the ensuing delay in homing diminishes the time available for the Sizzler to enter its high speed, evasive weave. This presents a better window of opportunity for surface units to engage in hard-kill tactics. The tactical commander can also choose not to employ hard-kill methods, because when confronted by large radar targets, RCS based seekers default to striking the center the returned radar energy. Knowing this, the SAG commander can place his units away from the center of the smoke cloud causing the ASCM to fly harmlessly into the water.[134] Such CT benefits effect all RCS based ASCMs, "C" series included.

The size of the M56E1 is relatively portable in terms of naval application as the Army employs it from the hummer vehicle.[135] Likely USN Coyote platforms are the SH-60, all

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[134] Morash, "Naval Obscuration," 13-15.

[135] A helicopter-borne Coyote can offer up to one and a half hours of obscuration in a single sortie, while warship-borne smoke missions are limited only by supply of obscurant materials. Unit cost for the Coyote is approximately $150,000 and 4 minutes of obscurant materials run roughly $1,000. Morash, "Naval Obscuration," 4; and Halsey Group Three Alpha, "Naval Obscurants" (Naval War College, n.d.): 4.

warships, and potentially the fleet USV.[136] Coverage of a surface group is achievable by approximately 6 Coyotes units. A team of M56E1s, distributed across surface and air platforms, can deliver a highly effective CT "smoke cloud" over U.S. SAGs. Combining this existing Army technology with USN World War II smoke screen tactics[137] provide the U.S. fleet a critical and affordable CT method.

E. CONCLUSIONS

> A major consequence of massing for defense is the certainty that the enemy will be aware of the fleet and its general location. Then, electronic-warfare tactics should be designed not to mask the presence of the fleet, which is impossible, but to complicate the enemy's efforts to track and target the key units carrying out the fleet's mission—in a word, its striking power.[138]

As Kline demonstrates using Hughes' equation, a less numerous fleet can achieve parity with a more numerous force if CT and or scouting are adjusted in favor of the fleet with inferior numbers. The distributed force and elevated ship count of the NNFM dramatically reduce CT and scouting measures necessary for U.S. surface ships to employ in order to surmount PLA-N numerical advantage. When including the non-missile combatants in the NNFM fleet, American numbers double that of the Chinese. This also reduces their chances at killing our missile shooters while depleting their missile inventory sooner.

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[136] Morash, "Naval Obscuration," 7-17.

[137] Halsey Group Three Alpha, "Naval Obscurants," 3.

[138] Hughes, *Fleet Tactics*, 292.

CT more than resolves numerical disadvantage. CT affords the tactical commander a vast array of SAG geometries he can exploit to bring favor on his side in combat. USVs fulfill the need for American ships to undergo the first wave of attacks, removing ROE restrictions, while leaving a predominate number of missile combatants left to conduct the first effective strike by means of a counterpunch. This CT capability is within reach by adjusting RCS profiles of fleet class USVs intended for acquisition by the DoN. It is crucial that the ASCM decoy role of the USV be realized and enacted upon in subsequent USV design.

LPDI pathways, such as the USAF's FALCON program, demonstrate the next level of communications the USN should strive for. These agile, high-speed networks open new realms of EMCON manipulation bringing in advanced levels of stealth and surprise to the U.S. surface forces.

Additionally, the U.S. has long understood the importance of soft-kill measures. Bringing the Army's M56E1 program into the maritime environment brings a CT capability that exceeds SRBOC, diminishes the SS-N-27 threat, and greatly reduces the effectiveness of PRC ASCMs across the board. The Coyote system is relatively low cost, and well understood, taking most of its risk in acquisition away.

Numbers are the biggest component to fleet preparedness and the PLA-N outnumbers the USN. If America stays her present course, she will always enter battle with the PLA-N at a deficit. Distributing and growing the surface force as per the NNFM study approaches parity. Applying CT techniques as discussed leverages advantage in American favor.

III. FLEET LIGHTER THAN AIR TECHNOLOGY (LTA)

In considering the factor of cost as applied to naval assets, it is wrong to think of high cost defining a vessel as unaffordable to lose in battle. The unit cost (actual dollars spent on acquiring, maintaining, and operating a ship) is potentially money sent to the bottom of the sea by enemy action—sunk cost. Sunk cost has no relevance in war. However, cost factors into preparedness. Preparedness is reflected in fleet numbers translating into the ability to appear around the world in significant force. When budget prevents procuring large quantities of high unit cost vessels, yet persists in acquiring high unit cost vessels in low quantities, an inflexible fleet is formed.

Not preparing for adequate fleet numbers is on the forefront of naval thinker's minds:

> Little more than 13 years ago, with the public release of the U.S. Maritime Strategy, then-Secretary of the Navy John F. Lehman Jr. effectively argued that a 600-ship Navy was necessary to meet a U.S. national-security requirement for maritime superiority. Remarkably, the Navy today is on the threshold of falling below 300 ships—the smallest fleet since 1931.[139]

The same article goes on to articulate the importance of weighing fleet numbers against potential military engagements in one generic theater of operation.[140] Taking

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[139] Kinney, "U.S. Engagement Strategy," under "Little more than 13 years ago."

[140] Ibid., under "Greater Reductions, Increased Risk."

such metrics to heart in the SCS, one can see the deficit into which the U.S. fleet might be placed.

The NNFM study addresses ways in which overall fleet numbers are enlarged with present SCN projections as discussed in the first chapter.[141] But, the NNFM only covers ships. Not yet discussed is the potential to augment fleet forces with airborne ships. Introduction of airships to the sea service not only provides on demand communications and ISR needs, but complements the Aegis weapons suite, lending to the more confident application of DDGs, CGs, and the strike groups they defend.

A. PRINCIPLES AND BACKGROUND OF USN LIGHTER THAN AIR TECHNOLOGY (LTA)

LTA provided mankind his first experience at flight, long predating the Wright brothers' famous exercise at Kitty Hawk, North Carolina.[142] Much has evolved in the LTA world since those first balloons took flight.

1. Design Principles

LTAs, or "airships," are classified into three distinct categories: non-rigid, semi-rigid, and rigid.[143] Recent advances have introduced a fourth design style

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[141] For detailed discussion on using the SCN budgets to build a numerically superior fleet see: Hughes, "Navy Fighting Machine."

[142] William F. Althoff, *Skyships: A History of the Airship in the United States Navy* (New York, NY: Orion Books, 1990): 12.

[143] Phillip W. Lynch, "Hybrid Airships: Intratheater Operations Cost-Benefit Analysis" (master's thesis, Air Force Institute of Technology, 2011): 1.

termed "hybrid." A quick description of the different variants of LTA craft will provide a better foundation for airship discussion.

A non-rigid airship is frequently referred to as a "blimp." A well known example is the Goodyear Blimp. "Non-rigid" is determined by:

> The internal pressure of the lifting gas (non-flammable helium) maintains the shape of the envelope, or the airship's polyester fabric skin. The only solid parts are the passenger car [gondola] and the tail fins. Internal air compartments, called ballonets, are inflated or deflated with air to compensate for ambient pressure differences. These airships have no internal framework.[144]

Semi-rigid airships are a logical extension of blimps characterized by, "a rigid lower keel construction and a pressurized envelope above that. The rigid keel can be attached directly to the envelope or hung underneath it."[145] Semi-rigid airship designs were widely used by the USN in its LTA era of 1915-1962.[146]

The third style of traditional LTA designs is the rigid airship, identifiable by:

> [A]n internal frame. The Zeppelins and the USS Akron and Macon were famous rigid airships. The rigid structure, traditionally an aluminum alloy, holds up the form of the airship. In general,

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[144] Goodyear, "Airship Types," (n.d.), http://www.goodyearblimp.com/cfmx/web/blimp/basics/airship_types.cfm, under "Non-Rigid."

[145] Ibid., under "Semi-Rigid."

[146] The Patuxent Partnership, "Airships, What You Think You Know," (n.d.), http://paxpartnership.org/Knowledgebase/Attach/10%20Pax%20River%20033110-ver01.pdf, under "US Navy LTA History."

rigid airships are only efficient when longer than 120 meters (360 ft) because a good weight to volume ratio is only achievable for large airships.[147]

LTA differs from heavier-than-air (HTA) flight due to fundamentally different lift principles. HTA uses Bernoulli's dynamic, demanding motion over the lifting surface to suspend the platform in air. Such motion requires the HTA to consume more fuel. The LTA, however, relies upon Archimedes' principle of displacement like a ship on the water. An airship needs much less fuel for propulsion, leaving the majority of fuel consumption for electrical generation and stationing.

All forms of airships undergo altitude and temperature changes causing lifting gases inside the envelope to fluctuate in both pressure and volume. "Ballonets," filled with ambient air, compensate for the lifting gases' expansion and contraction. At higher external pressures, experienced at lower altitudes, the ballonets are at their fullest. As the airship climbs and the lifting gases expand, the pilot releases air from the ballonets. Once all ambient air is expelled from the ballonets, the airships is said to have reached "pressure altitude." Any further climb in elevation requires lifting gas, helium, to be released or the envelope will potentially burst. Figure 12 is a diagram of a typical airship envelope and ballonet system.

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[147] Goodyear, "Airship Types," under "Rigid."

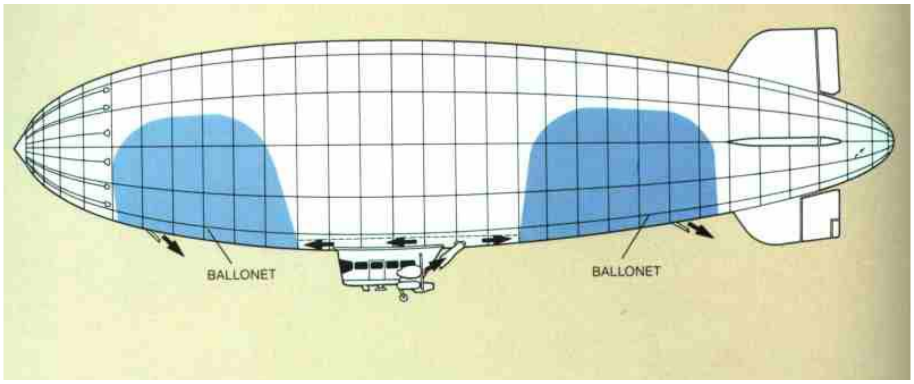

Figure 12. Diagram of Airship Showing Ballonets. From[148]

The above diagram helps visualize an airship's advantage. The main envelope, in addition to providing buoyancy, can house large pieces of equipment. Thus, the volume of the envelope is like the interior spaces of a warship. The area inside the envelope is quite useful for mounting large radar dishes, electronic jamming gear, communications suites, and so on. The size of the gear does not matter as the envelope and power generating sources can scale to accommodate (similar to ship classes which scale in displacement to facilitate larger arrangement of equipment). As the discussion continues, adaption of this free space inside the envelope will undergo examination.

Hybrid airships are frequently classified as LTA crafts. Technically speaking, they are HTA platforms requiring motion or vectored thrust to achieve flight. For this discussion however, hybrids are grouped under LTA.

[148] Jens Schenkenberger, "Information About 'Non-Rigid Airships'," (n.d.), http://www.zeppelinfan.de/htmlseiten/englisch/luftschiff_prall.htm.

Generally, hybrid airships obtain 70% of total lift from helium within their envelopes, while the remaining 30% is created aerodynamically.[149] Visibly different from the classic airships, the hybrid's envelope consists of "lobes" creating a flatter, horizontally elongated, wing-like volume that induces lift while the airship is in motion (see Figure 13).

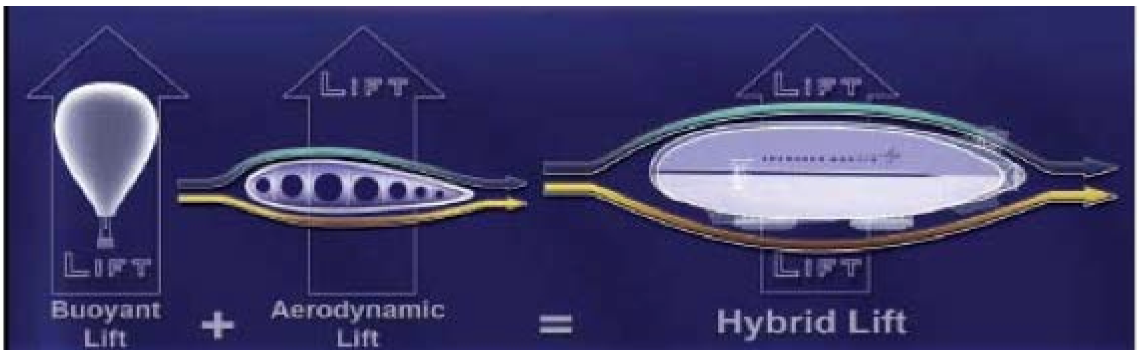

Figure 13. Hybrid LTA Lifting Principles. From[150]

The hybrid is a highly viable type of airship. Its strength lies in the minimal support needed in airfield facilities and personnel for launch and recovery procedures. A traditional airship requires more orchestration from ground crews due to its continuous lift characteristic that must be appropriately ballasted. Nonetheless, both forms of LTA offer true off airfield capability.[151]

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[149] U.S. Navy Naval Air Systems Command, "Hybrid Aircraft Envisioned Military Relevance: Report to EUCOM S&T Conference" (Stuttgart, Germany: EUCOM, 2007): 4.

[150] Dan Fisher, "White Paper: Hybrid Aircraft Survivability" (Marietta, GA: Lockheed Martin Aeronautics Company, 2006): 4.

[151] Naval Air Systems Command, "Hybrid Aircraft," 9-12.

It is the lift and volume characteristics that make the traditional LTA vessel a greater ISR platform than hybrids or HTAs. Naturally suspended at altitude, while converting a high percentage of its fuel into power for electronic suites, the non-hybrid LTA reaches endurances far exceeding other aircraft. For the NNFM in the SCS, the C4ISR platform of choice is the traditional airship.

To say hybrids do not have a place in military operations is short sighted. The marriage of enormous airlift, on the scale of 500 tons, without the assistance of developed airfields makes the hybrid an incredible cargo asset. The U.S. Army is considering hybrids as a potential "fort to fight" platform that can forego unit transport via highway, rail, cargo ship, or airplane. Such delivery offers improved unit cohesion, reduced transit time, and lower transit cost.[152]

For the USN, hybrid utilization could lead to a highly mobile, and expedient supply chain delivering fuel, bullets, and beans to the battle groups at sea with minimal protection by the combatants. Additionally, a hybrid resupply airship foregoes or reduces the threat from submarines, mines, pirates, underwater navigational hazards, heavy seas, and FAC.

2. Graceful Degradation

Lacking the requirement of constant motion for lift, the airship has the added advantage of graceful degradation

[152] Naval Air Systems Command, "Hybrid Aircraft," 4-14.

upon attack. Lockheed Martin studied the effects of munitions strike on airships using the latest envelope materials (see Table 8).

Table 2. AAA Threats vs Time To Loss Of Lift.

Weapon	AK-47	NSV	ZU-23-2	2S6	Type 74	S-60	Otto Melara	Type 59
Caliber (mm)	7.62	12.7	23	30	37	57	76	100
Sustained Rate of Fire (rpm)	100	500	400	3000	400	70	80	15
# Rounds in magazine	30	150	50	1904	1000	4	80	1
Max Effective Range (m)	1500*	1000	2500	3800	2560	6000	12000	13700
Max useable rounds	108	360	720	1904	1000	302	80	148
Max hole size (ft2)	0.05	0.49	3.22	14.49	11.57	8.29	3.91	12.51
Loss Rate (lb/hr)	186	1723	11,310	50,860	40,640	29,120	13,720	43,930
Time to Forced Landing (hrs)	5669	619	93	21	26	36	77	24

Table 8. Threat Versus Time to Loss of Lift for LTA. From[153]

A difficult concept to grasp for the person new to the LTA platform is its ability to stay suspended in air after receiving attack. This feature is akin to a ship staying afloat even after its hull has been pierced, but instead of water rushing in, lifting gases are leaking out.

Some arguments have arisen declaring the airship unsuitable for military use because it is susceptible to anti-aircraft defenses (AAD) and the nature of war sometimes requires LTAs to go into heavily defended,

[153] Fisher, "Hybrid Aircraft Survivability," 12.

sovereign airspaces.[154] The authors offer that LTAs can serve the DoD, particularly the Department of the Navy (DoN), extraordinarily well in the international airspaces of the open seas with no need to overcome AAD. However, as the above table shows, 21 hours after receiving AAD hits the airship gracefully lands. The resilient flying capacity of an aircraft despite sizable damage is foreign to most military thinkers, authors included. Graceful degradation affords the opportunity for the platform to persist in its mission, as well as providing ample time for the crew to plan for rescue if return to base is not accomplishable.

3. USN LTA Program

The catalyst for the USN to create an LTA program stemmed from the German’s first maiden flight in 1900 of their zeppelin airship LZ-1. The airship had military potential spurring fears amongst American leadership of falling behind the technology curve. Those predictions came true when Germany used zeppelins to conduct air raids on the Allied in August 1914. Although the raids proved less than ideal, the airships enjoyed advantages as scouts in maritime patrol and fulfilled a major mine warfare role against Great Britain. German preeminence in LTA employment pushed the U.S. to develop an airship program as well. Although the war ended in 1918, Congress mandated that the USN establish an LTA Naval Air Station in Lakehurst, New Jersey. The LTA fleet consisted of two airships at the

[154] William Matthews, "Deflated: America's Airship Revolution is Threatened by Mishaps, Delays, Funding Cuts," *C^4ISR Journal* 11, no. 4 (May 2012): 18.

time: one purchased from the British (ZR-2), and its domestically constructed counterpart (ZR-1) commissioned as the United States Ship (USS) Shenandoah (pictured in Figure 14).[155]

Figure 14. USS Shenandoah (ZR-1) Moored at Sea to USS Patoka (AO-9), circa 1924. From[156]

The program peaked at 292 airships,[157] but suffered a decline with the popularity of fixed-wing aircraft.[158] Throughout World War II and into the late 1950s, the airships remained numerous and viable. Due to the speed and maneuverability of an airplane the airship took a secondary role in the military flight community. An added factor was:

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[155] Althoff, *Skyships*, 4.

[156] Naval Heritage and History Command, "Photograph Number 57994," 1924, http://www.history.navy.mil/photos/ac-usn22/z-types/zr1-h.htm.

[157] Patuxent Partnership, "Airships," under "US Navy LTA History."

[158] Congressional Budget Office, "Recent Development Efforts for Military Airships," November, 2011, http://www.cbo.gov/sites/default/files/cbofiles/attachments/11-01-Airships.pdf.

> [I]mprovements to antiaircraft weapons during and after the war led military planners to conclude later that airships would be too slow and too vulnerable to attack from the ground, particularly when facing a technologically capable adversary such as the Soviet Union. Therefore, interest in airships waned.[159]

These analysts are correct to point out the disparity between the airship and HTAs in regard to AAD, and air-to-air combat (AAC). HTAs enjoy advantages in speed and maneuverability that LTAs cannot match. Were AAD and AAC concerns reason enough not to consider an airborne asset worthy of DoD investment, where would the U.S. be without the services of air-to-air refuelers, maritime patrol aircraft, search and rescue helicopters, cargo planes, unmanned aerial vehicles (UAVs), airborne warning and control system (AWACS), and take charge and move out (TACAMO) aircraft?

4. Prejudice

In sifting through LTA history and by speaking with members of the communities involved it is the opinion of the authors that obsolete prejudice against LTA technology prevents its proper adoption for military application.

It is time to lift the veil from LTA and formulate appropriate applications of airships by noting their advantages in fuel consumption, power availability, and persistence. It is unwise to predict how much benefit is gained from airships, but it is emphatically unwise to

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[159] Congressional Budget Office, "Military Airships," under "Background."

dismiss their potential. Given the budgetary climate of the DoD, the resource conservation aspect of LTA excites interest as well as spurs rebuke, especially from programs looking to survive in lean times.

Aside from this, the Hindenburg tragedy still persists in the minds of some. Modern airship construction is vastly different than LZ-129 Hindenburg. Hindenburg's rigid envelope was painted with a varnish containing aluminum powder in order to give the zeppelin its trademark silver appearance. Aluminum in this form is essentially solid-state rocket fuel. It fed the visible flames captured on film that fateful day. Hydrogen was used as the lifting gas. However, when hydrogen burns it is invisible to the human eye and has been discredited as the source of the Hindenburg fire. Nevertheless, current airship designs employ the use of helium, as it is a fire suppressant. Similarly, modern envelope materials vastly improve airship safety.[160] It is time to move past the Hindenburg incident as has been done with the Titanic.

Most importantly to some, airships look like an odd duck. Questions of whether it is piloted by aviators or submariners, or rather commanded by surface warriors all address issues of form, not function. Adoption by a warfare community and the creation of new traditions will play out in the airship realm over time. Troubling oneself about LTA's effect on image is not strategically, tactically, nor operationally important. Place the mission first.

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[160] Fisher, "Hybrid Aircraft Survivability," 7.

5. Resurging Interest in LTA

There are four root principles that make airships an attractive platform:[161]

1. Fuel efficiency coupled with high fuel prices.
2. Persistent airborne ISR.
3. Airborne platform with little gyration removing hardening requirements for electronic suites.
4. Immense adaptability in volume and payload for cargo operations.

Adoption of LTA technology in today’s military is a necessity due to its ubiquitous application and "greener" energy consumption. As an ISR asset, it would provide invaluable persistence surpassing any other single ISR platform we have at our disposal today with the exception of satellites.

Additionally, LTAs do not cause stress on their equipment as do HTAs. Helicopters and airplanes, through a combination of vibration, speed, and maneuvering, require on-board equipment to be especially hardened for their demanding operating environment. The airship, as a fast moving, steady sailing ship, does not require such hardening. Commercial grade electronics are flyable on LTAs, reducing cost burdens of making military-grade equipment, as well as facilitating a fertile platform for technology experimentation and upgrades.

In a satellite-denied environment, the airship can establish links with other LTA craft and create a pathway back to an unblocked satellite, ground stations, or SAGs.

[161] Four LTA principles of interest developed by Chuck E. Myers, Jr., in his proposed article, "Airships, Why Now?" submitted to *Proceedings* magazine. Provided to authors via e-mail. Article not yet published.

As an ISR asset, the tactical commander can make timely decisions by monitoring friendly and enemy movement through the vantage point of high, networked airborne systems. Knowing where friendly and enemy combatants are moving through the battle space allows him to coordinate and vector ships or weapons with confidence, while anticipating his opponent's actions.

Recently proposed DoD airships have undertaken many designs. Figure 15 summarizes the different styles, sizes, and operating altitudes of prospective DoD LTA platforms. Make special note of the Blue Devil II airship under the low-altitude ISR section, to which we will return to later.

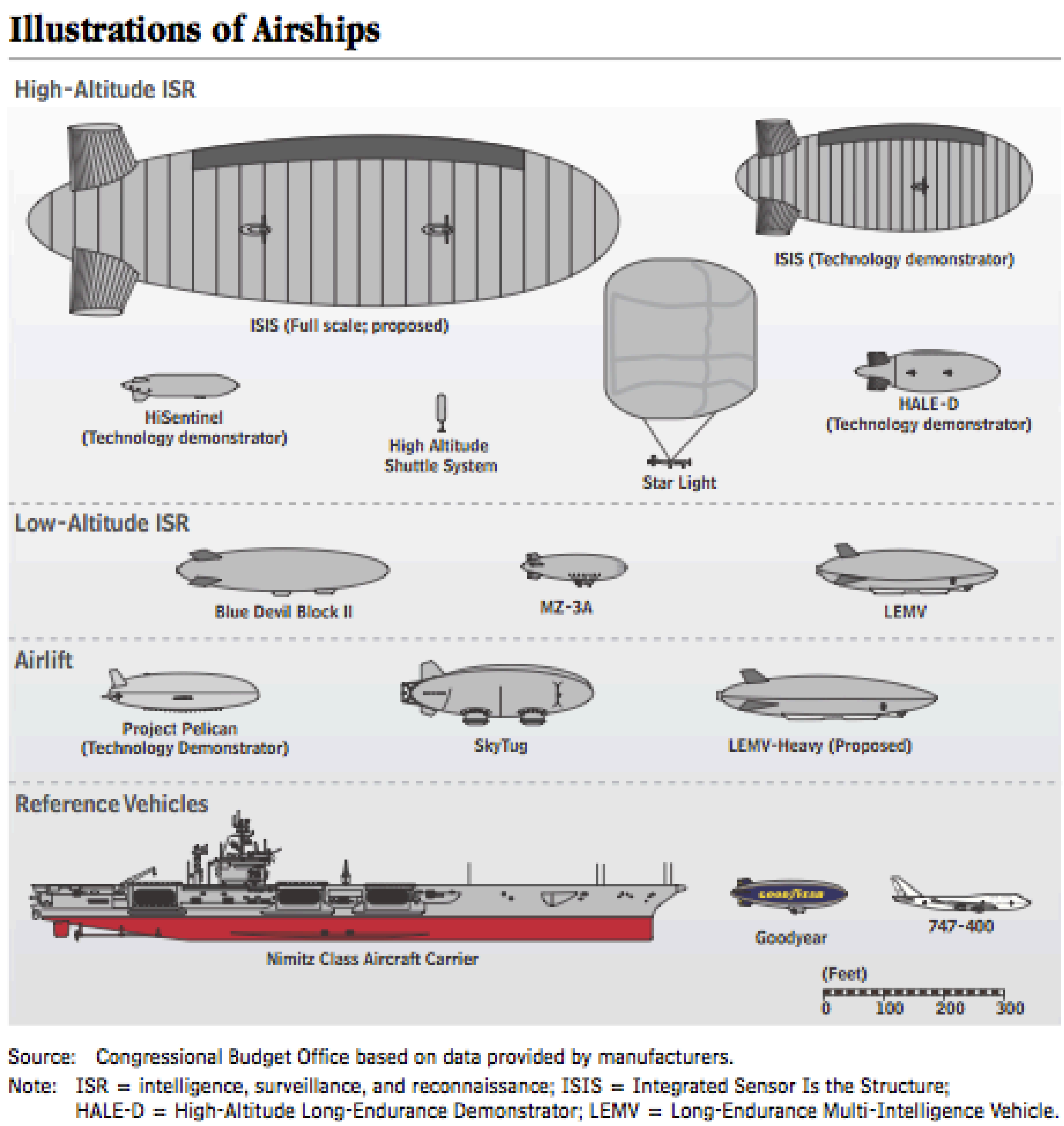

Figure 15. Summary of Proposed DoD Airships. From[162]

[162] Congressional Budget Office, "Military Airships," under, "Illustrations of Airships."

B. LTA AS AEGIS OVER THE HORIZON TARGETING (OTHT) PLATFORM

Formidable as the Aegis radar is, a shortcoming lies in its line of sight (LOS) limitation caused by the curvature of the Earth. This phenomenon creates a highly vulnerable low altitude attack vector. This has spurred enemy development of sea-skimming ASCMs and low approach tactics in combat aviation.[163]

With this in mind, PLA-N ships or aircraft armed with C-802s can stand off from USN forces up to 100 nm and fire a volley of missiles.[164] Using unclassified numbers, the PLA-N offensive pulse will go unseen by the USN Aegis missile system until roughly 18 nm from the SAG. This leaves around 100 seconds for the American surface forces to notice, track, target, and neutralize the strike.[165] Should the PLA-N strike with the SS-N-27 instead, approximately 9 seconds are afforded an SM-2 strike before Sizzler transitions into its highly evasive, terminal weave.[166]

This discussion is not aimed at determining if Aegis will defeat the PLA-N pulse in the time frame mentioned above, but rather to offer a means of extending this

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[163] Low approach tactics were used by the Argentine Air Force in the Falkland War as captured by ADM Sandy Woodward, RN, in his book *One Hundred Days*.

[164] As per I.A.2.a.7.

[165] The authors offer these numbers for illustrative purposes for the unfamiliar reader. It is understood that classified analysis on the topic exist. For calculations Aegis is assumed to have a height of eye of 100 ft, Saccade missiles height is 20 ft, and Saccade speed is 0.9 Mach.

[166] Morash, "Naval Obscuration," 17-18.

engagement window further out from U.S. forces in order to improve the defensive power of the American SAG in the SCS (see Figure 16).

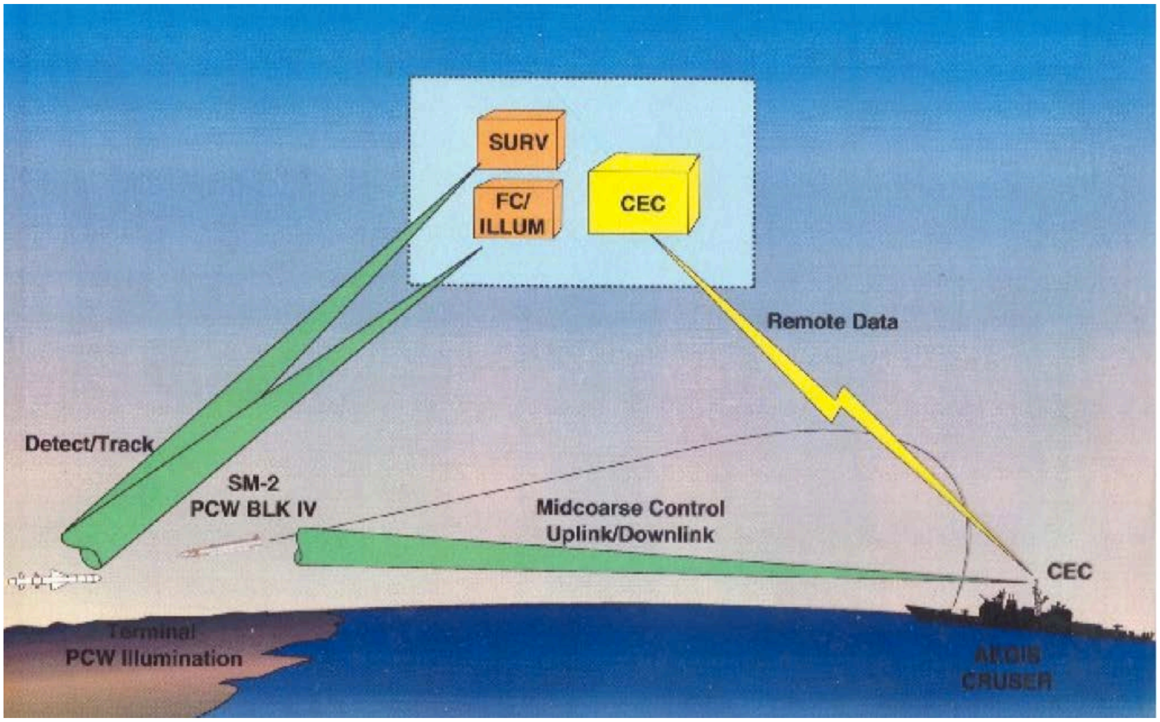

Figure 16. Aegis Airborne Adjunct. From[167]

An airborne Aegis adjunct overcomes the limitations of the ship's LOS and multiplies the SAG's detect-to-engage sequence window. Wayne E. Meyer, the driving force behind the Aegis weapon system, notably stated that the air adjunct is, "[A]bsolutely vital and complementary for the battle force."[168] Current observation of Aegis yields the same conclusion. This multi-billion dollar weapon, so

[167] Chuck E. Meyers, Jr., "U.S. Navy Lighter-Than-Air Airship Program For Fleet Defense" (Gordonsville, VA: Aerocounsel Inc., n.d.): 7.

[168] Quoted from a personal letter written by Wayne E. Meyer dated March 7th, 1982 and retained on file by the authors.

effective against targets it can see, has this Achilles heal. The prestige and cost of the Aegis warship makes it even more critical to protect with reliable eyes in the sky.

The current Navy plan to satisfy the need is to develop an HTA platform. The crux of the problem is detecting sea-skimming shapes the size of missiles or larger. One answer the authors do not endorse is to affix an Aegis radar to an air platform. Power, cooling, and space limitations make airborne Aegis exceedingly difficult.

An alternative is to give the air element a less sophisticated radar and fire control system. The primary problem with this approach arises when the radar system tries to distinguish low flying objects from sea clutter. The radar definition required to achieve the level of fidelity needed to distinguish a missile-sized objected from a wave top again drives to cumbersome sizes.[169]

An analysis of applying such a radar dish to an HTA was conducted in the late 1980s by the Center for Naval Analyses (CNA).[170] It was determined that a 48 ft by 13 ft radome could be affixed 15 ft above the fuselage of a Boeing 747 as shown in Figure 17.

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[169] Meyers, "Airship Program," 5.

[170] Center for Naval Analyses, *Airship Operational Utility Analysis*, Report 94014800 (Alexandria, VA: Center for Naval Analysis, 1988) quoted in Meyers, "Airship Program," 16.

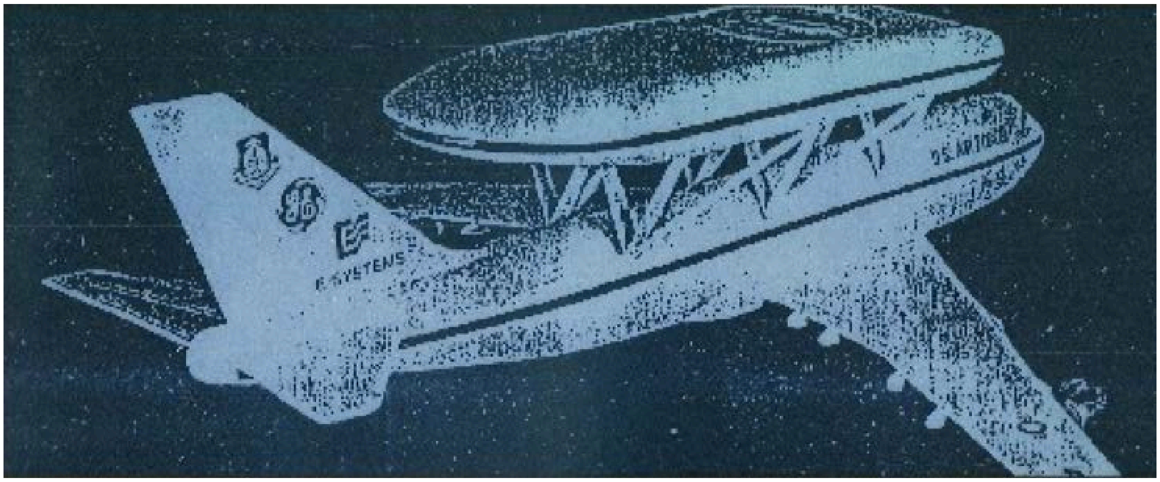

Figure 17. HTA Aegis Adjunct: 747 with Radome. From[171]

Even large HTAs such as the 747 do not carry the space necessary for illuminators thereby foregoing the requirement to extend the SM-2's engagement window against the low approach threat. Additionally, the threat is an around the clock real world problem. A symphony of land based 747s relieving each other in procession used to maintain a continuous watch over the battle group is infeasible. A more practical solution is presented in Figure 18.

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[171] Meyers, "Airship Program," 25.

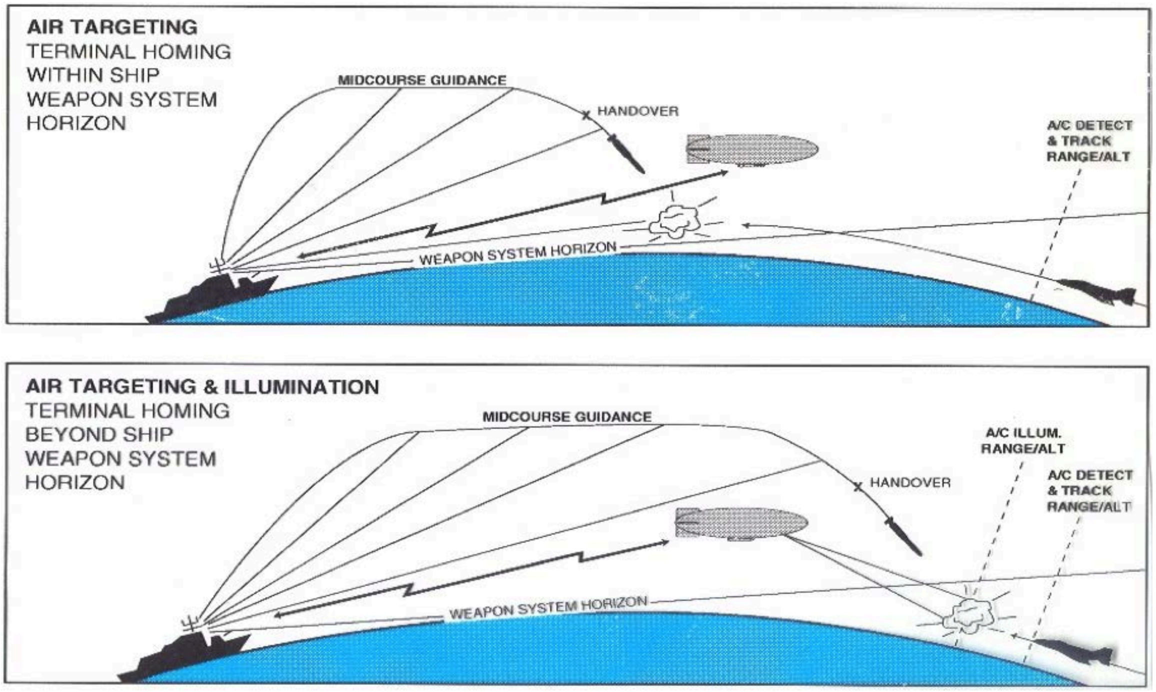

Figure 18. LTA as Full Aegis Adjunct Complete with Illuminators. From[172]

On the other hand, employing an LTA as the airborne Aegis adjunct resolves the time on station problem, the power requirement, and spatial needs to house the large radar and illuminators. Recall how space inside an LTA's envelope, aside from the ballonets, is free for mounting equipment (see Figure 12). That space can house a radar large enough for this particular mission. To assist in the perspective of scale, Figure 19 shows the relation between a 747 and a formerly commissioned USN airship YEZ-2A.

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[172] Meyers, "Airship Program," 8.

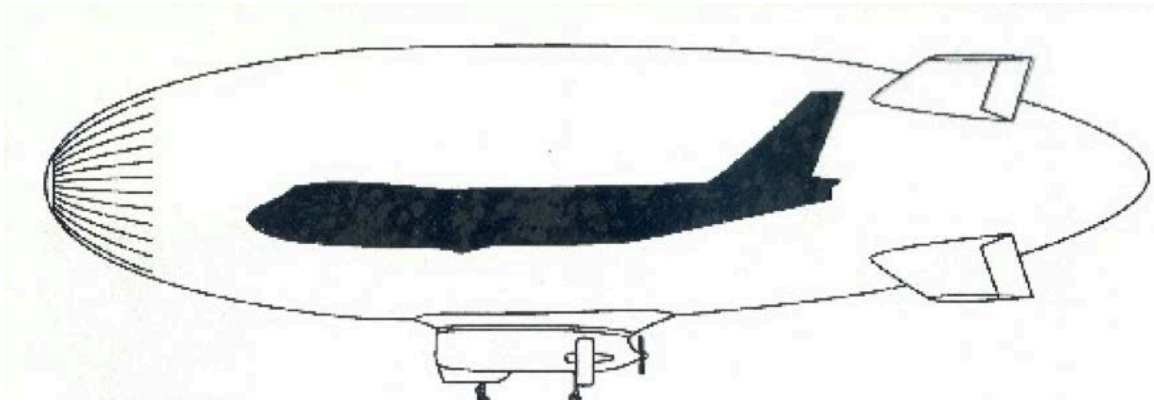

Figure 19. Boeing 747 and Airship YEZ-2A. From[173]

The low flyer threat to Aegis hinders confident and widespread use of American Destroyers and Cruisers. Aegis' Wayne E. Meyer saw the prudence of including an air adjunct and notably understood that LTA, not HTA, could only properly fulfill such a role. Creating an airship based on the dimensions and capabilities of former USN airship YEZ-2A brings a platform large enough to house the required radar and illuminators to extend Aegis' and the SM-2's engagement window further out from the SAG. The SA brought by such an airborne asset will also ease the burdens of defensive counter air stations (DCA), which consume such a large portion of the carrier strike group (CSG) operations. A highly developed system such as Aegis needs the best ISR that can be provided to safeguard America's fleet and its personnel.

[173] Meyers, "Airship Program," 24.

C. C4ISR AIRSHIP IN THE SCS

1. The USAF Blue Devil II as NNFM C4ISR Airship

A needed application of LTA technology for the surface fleet in the SCS is a C4ISR airborne node giving the American commander SA, LPDI communications, and better EMCON measures, while burdening PLA-N commanders with another layer to overcome. As demonstrated, many variants of airships are available for application. A principle of the NNFM however is exploiting platforms already understood and relatively low cost in order to multiply the effectiveness of the U.S. fleet while avoiding risky new developments. The well-developed USAF Blue Devil II (BDII) airship program offers a robust and viable C4ISR node to USN forces in the SCS. It is a pertinent starting point for renewed USN LTA endeavors.

BDII is a moderately sized airship with an overall length of 350 ft, envelope volume of 1.3 million ft^3, a max airspeed of 80 kts, and a max altitude of 20,000 ft (see Figure 20). Suspending two gondolas, the BDII offers a compartment for piloting controls and mission payloads forward and an aft car containing propulsion and power generating equipment. The forward gondola measures 23 by 10 by 7 ft. An important feature of the command car is its ability to accommodate interchangeable C4ISR packages based on the North Atlantic Treaty Organization (NATO) 463L universal air pallet system. Palletization of C4ISR gear allows mission payloads to be interchanged by ground crews in less than four hours. Max payload aboard BDII is 7,500 lbs with a 3 day mission endurance. At payloads of 2,500 lbs or less mission times in excess of five days are achievable.[174]

Figure 20. Blue Devil II. From[175]

BDII arose from a Combatant Commander's (COCOM) integrated priority list (IPL) specifying the need for detecting improvised explosive device (IED) insertion in Iraq and Afghanistan. An airborne motion sensing ISR platform was the most viable solution. However, persistence is key to effective ISR, something HTA UAVs with staying times under 24 hours could not feasibly provide. Analysis of alternatives showed an airship to be a worthy platform for this mission and was thus the genesis of BDII.[176]

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[174] Jane's Unmanned Aerial Vehicles and Targets, "MAV6 M1400-I Blue Devil II," September 9, 2011, http://juav.janes.com/public/juav/index.hstml, under "Mission Payloads."

[175] Clay Dillow, "Blue Devil Airship is Getting a Super-High-Speed Optical Laser Downlink Upgrade," *Popular Science*, 30 November 2011, http://www.popsci.com/technology/article/2011-11/usafs-blue-devil-airship-getting-super-high-speed-optical-laser-downlink-upgrade.

[176] Jane's Unmanned Aerial Vehicles and Targets, "MAV6" under "Development."

In describing the capabilities of the BDII, the Joint Improvised Explosive Device Defeat Organization (JIEDDO) describe the airship as a:

> [U]nique, developmental, integrated, multi-intelligence, auto-tipping and cueing C-IED [Counter Improvised Explosive Device] airborne Intelligence, Surveillance and Reconnaissance (ISR) [platform that integrates] the highest resolution wide field-of-view electro-optical sensor with high-definition cameras and signals intelligence geo-location sensors.[177]

While the Defense Technical Information Center (DTIC) details:

> The Blue Devil II system is an Air Force led single ship technology and concept demonstration of multi-intelligence, cross-platform tipping and cueing of fused SIGINT [signals intelligence], wide area and high-definition EO/IR [electric optics/infra-red] motion imagery on a persistent lighter-than-air airship.[178]

The USAF further imposes the following systems on BDII: the Sierra Nevada Gorgon Stare and BAE Systems/Lockheed Martin autonomous real-time ground ubiquitous surveillance imaging system as wide-area airborne surveillance sensors (WAAS),[179] the Tactical Targeting Network Technology (TTNT), the Tactical Common

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[177] Jane's Unmanned Aerial Vehicles and Targets, "MAV6," under "Development."

[178] Defense Technology Information Center, "RDT&E Budget Item Justification, PB 2012 Air Force" (Fort Belvoir, VA: DTIC, February 2011), http://www.dtic.mil/descriptivesum/Y2012/AirForce/0305205F_7_PB_2012.pdf.

[179] UAS Vision, "US Air Force Funds $86M Blue Devil 2 Demonstration Airship," April 11, 2011, http://www.uasvision.com/2011/04/11/us-air-force-funds-86m-blue-devil-2-demonstration-airship/.

DataLink (TCDL), and the Remotely Operated Video Enhanced Receiver (ROVER).[180] The resulting mixture of technologies are summarized in the Figure 22.

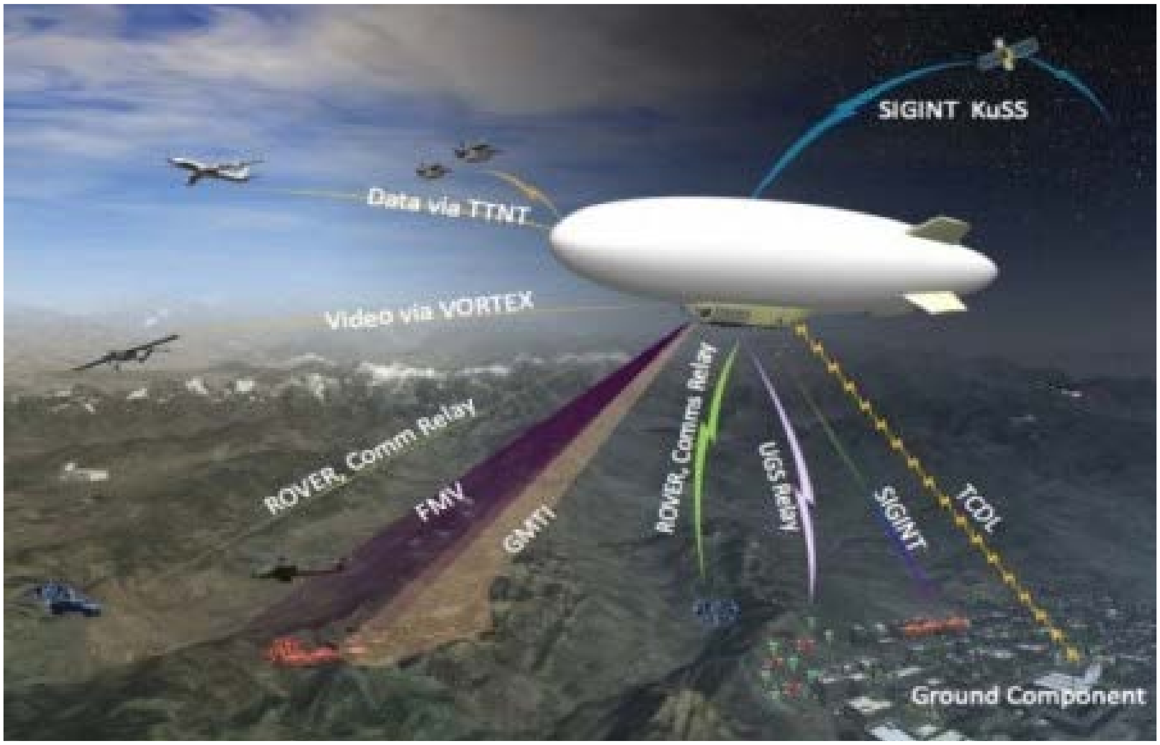

Figure 21. Blue Devil II Concept Diagram. From[181]

Overcoming the jargon and new technologies can be problematic with BDII. MAV6, the company responsible for creating BDII, succinctly describes the true mission of its LTA platform as, "[A]irship-based C4ISR aerial fusion node and weapon system platform."[182] The numerous technologies all have application and potential in DoD service. It is,

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[180] Jane's Unmanned Aerial Vehicles and Targets, "MAV6," under "Description."

[181] UAS Vision, "Blue Devil 2."

[182] MAV6, "M1400-I Optionally Manned Airship," n.d., http://mav6.com/Mav6-Blue-Devil-Airship.pdf.

however, acceptable to scale back the experimental technologies and outfit BDII airship with proven C4ISR gear. Such a marriage produces invaluable intelligence and communications capabilities with sustained operating times.

The C4ISR airship can dramatically shift the advantage in favor of the U.S. in the SCS. A proven example of airborne ISR technology available for adoption to airship use is the Orion EP-3 variant. Arising from increasing ISR demands of the Afghanistan and Iraq wars, the P-3 underwent numerous signals intelligence (SIGINT) upgrades. The combined intelligence and detections suites fall under the Airborne Reconnaissance Integrated Electronics Suite (ARIES) II heading.[183] Highlights of ARIES II include:

- AN/ALR-76 radar band electronic support (ES) system
- AN/ALR-84 radar band processor/receiver
- OE-319 "Big Look" antenna group
- AN/APN-234 weather/navigation radar
- AN/APS-134(V)2 surveillance radar
- OA-9306/A video distribution units
- AN/ALQ-10 indentify friend or foe (IFF) countermeasures set
- AN/USH-33(V)2 data recorder set[184]

The list of available and proven DoD C4ISR systems adaptable to airships are too numerous to mention. What the authors wish to show is that well-established RF communications paths, video and radar surveillance, and

[183] Jane's Electronic Missions Aircraft, "Lockheed Martin EP-3E," March 23, 2012, http://jema.janes.com/public/jema/index.hstml.

[184] Ibid.

data path nodes are applicable to LTAs. The NNFM envisions these capabilities airborne and continuously available to the SAG commander in a distributed constellation of airships across the SCS.

2. NNFM C4ISR Airship SCS Operations

a. Operating Area

As pictured in Figure 22, the primary area of operations in the SCS is a 700 by 1,200 nm "box."

Figure 22. SCS Operating Area. From[185]

At the southern reaches of the box it is likely that carriers and other high value units are able to operate outside the threat of DF-21's 1,000 nm range.

[185] Crowder, "Storm Warnings," 22. Red box overlay created by authors.

However, progressing inwards increases problems for the U.S. surface fleet as PRC A2AD increases.

b. C4ISR, Footprint, and Manning

An important facet of potential conflict in the SCS is the "deterrence phase," which is a pre-conflict time in which the U.S. can best shape the potential battle space in its favor. A tremendous ally is the C4ISR LTA constellation providing continuous, real-time tracking of PLA-N forces. The constellation of airships provides a data network potentially in the gigabit per second range (employing a laser based communications system such as FALCON), downlinks back to the terrestrial network, RF communications redundancy, and a theater-wide Link 16 for a common operating picture (COP). Figure 23 depicts how a constellation of airships such as the BDII can cooperatively provide satellite type C4ISR.

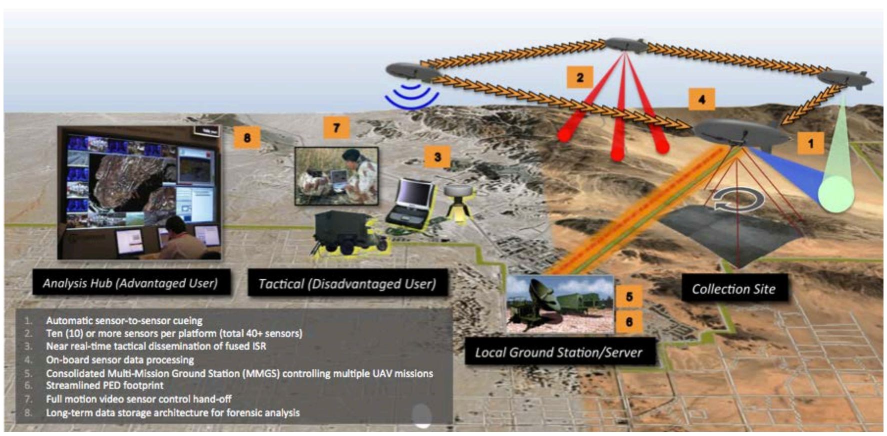

Figure 23. C4ISR Airship Constellation Conceptual Diagram. From[186]

[186] MAV6, "M1400-I Optionally Manned Airship," under "ISR Constellation."

It is recommended that each of our C4ISR airships is manned rather than be remotely operated. Outweighing the risk to personnel, the LTA's persistence in mission during armed conflict serves the greater needs of overall fleet operations in the SCS. Remote guidance introduces several factors that could lead to C4ISR airship mission failure: reliance on GPS, inability to recover from EMP attack, lack of casualty control or trouble shooting for C4ISR system failures, and inability to prudently determine when to abandon station or persist in mission in the event of envelope damage.

The envelope ceiling of BDII is 20,000 ft, but introducing aircrews brings the LTA's operating altitude down to 10,000 ft. This is to accommodate habitability requirements for personnel in an unpressurized cabin. A 10,000 ft ceiling simplifies the technical aspects of the airship used, reduces cost in operation and maintenance, while potentially sidestepping roadblocks more complicated systems experience in the acquisition process.

Our C4ISR airship's footprint at operating altitude is therefore 250 nm. Coverage of a 700 by 1,200 nm SCS operating area is achievable by a constellation of 15 airships as pictured in Figure 24.

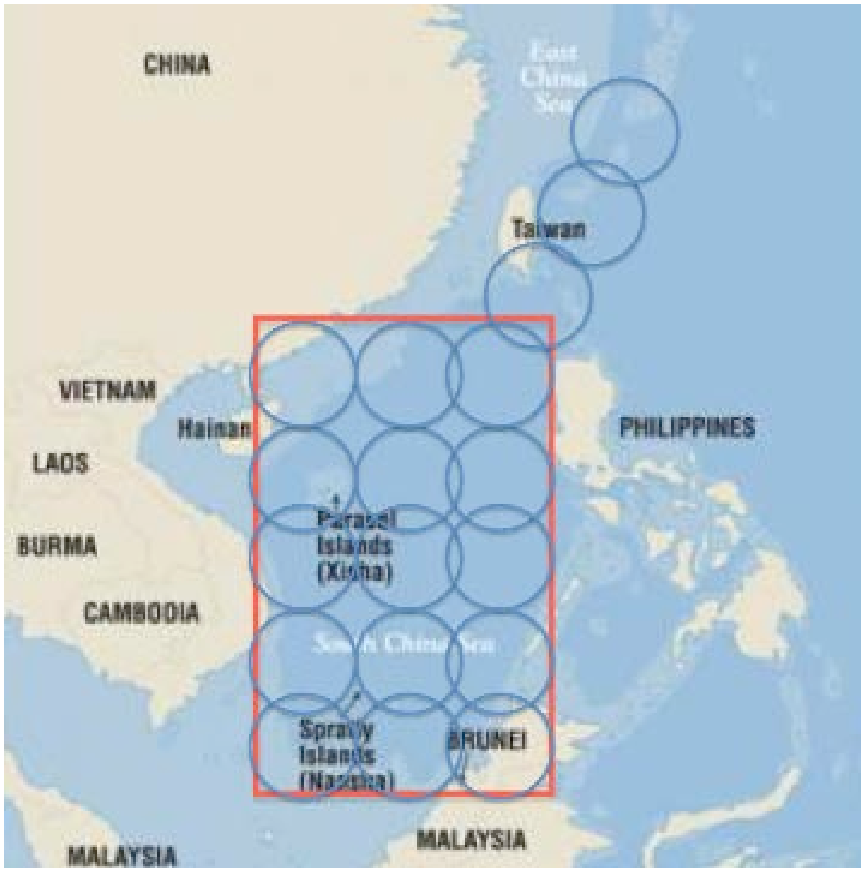

Figure 24. NNFM C4ISR Airship Constellation Operating Area (A Circle Depicts a 250 nm Footprint)

In the northeast corner one notices three LTA circles transiting from the SCS towards Okinawa. These additional LTA stations link back to the terrestrial network in Okinawa if access to the global information grid (GIG) via Vietnam, the Philippines, and Malaysia were denied. It is understood by the authors that GIG entry stations in those areas do not yet exist. It is our recommendation that redundant access sites are established in the terrestrial environments surrounding the SCS, facilitating a cascading mode of entry for American forces into the DoD network.

To that end, it is also foreseeable that the NNFM airship constellation network might better serve American strategy if it is independent of the GIG. During conflict, it is possible that PRC cyber forces will infiltrate elements of the DoD network. In that case, a stand alone, theater area network (TAN) provided by the airship constellation might prove invaluable. The Maritime Operational Commander (MOC) could securely direct U.S. surface forces in the SCS via the constellation network while reaching back to higher authorities via highly secure measures such as the Joint Worldwide Intelligence Communications Systems (JWICS). In this configuration, the MOC serves as an air-gapped bridge between national and airship constellation information networks.

c. Basing, Transit Times, and Endurance

We must not ignore basing for the airships in the region. Ideally the Philippines would serve as the primary base. Proximity of the Philippines to the operating area makes the longest transit time for an airship 12 hrs to reach the southwest corner.[187] Average stationing time for the constellation is approximately 6 hours, but on station time will be upwards of 90 hours.[188] Suspicion of the Philippine government towards the PRC, combined with a

[187] BDII max airspeed is 80 kts and distance to southwest corner of operating box is 950 nm.

[188] Based upon 120 hr endurance and max overall transit time of 24 hrs.

history of cooperation with the U.S., and advantageous geographical position makes this location the best spot for airship basing.

Vietnam should also be considered. Of the surrounding locations that are likely to oppose PRC action, Vietnam offers the lowest transit times for airship stationing. The northeast and southeast corners of the constellation box would each take just under 9 hours to reach, for an average transit time of 5 hours.[189] Vietnam basing results in LTA times on station around 100 hrs.[190]

Geographically less ideal are basing airships in Okinawa or Singapore. These two areas, already home to DoN operations, offer a reliable location to stage airship operations should assistance from Vietnam or the Philippines not be possible. Representative of LTA proceed times for Singapore as well, Okinawa's farthest transit is 18 hours to the southwestern operating area. Average time to station from Okinawa is 12 hours yielding a time on station upwards of 80 hrs.[191]

d. Vital Airship Constellation EMCON Benefits

Traditionally, ships at EMCON forego SA and radar tracking capability so as to go undetected by the opponent. Outfitting both SAG ships and C4ISR airships with LPDI communications such as FALCON provide the commander

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[189] Far corners of the constellation box are 700 nm from Vietnam coast.

[190] Based upon 120 hr endurance and max overall transit time of 18 hrs.

[191] Endurance based on 120 hrs with a max transit time of 36 hrs.

continuous communications both within and beyond the battle group. Additionally, stealthily tracking a PLA-N adversary through the network of C4ISR airships gives the American commander incredible agility in choosing when and where to engage an opponent. The value of LPDI communications to a C4ISR constellation allowing the SAG to operate with SA at EMCON cannot be adequately expressed in words. It is potentially a game changer in fleet on fleet engagements.

e. Misdirection using Airships

(1) During peacetime operations, the SAG should deploy with the airship operating continuously over the center of the group. An opponent, such as the PRC, may equate locating American surface combatants with finding the LTA. In war however, the SAG can proceed at EMCON at the outskirts of the LTA's footprint thereby misdirecting their location while maintain LPDI communications and SA.

Further advantages in misdirection might outweigh the loss of overhead connectivity of the SAG with the airship if misdirection results in a surprise offensive pulse. This is potentially achievable if the SAG proceeds ahead of their LTA footprint arriving within striking distance of the PLA-N in advance of what the opponent commander expects.

(2) The entire constellation of C4ISR can potentially shift hundreds of miles in a direction, leaving a portion of the SCS uncovered. An uncovered portion might lead PLA-N commanders to assume USN forces do not intend to operate within that area. Such an assumption may reduce the number of PLA-N forces left in that location, making a

strike by the U.S. fleet more successful. Additionally, such fleet engagements offer the advantage of surprise for the American forces.

Further geometries between the SAG and the airship abound, offering additional tactical possibilities. The tactics offered here are examples to demonstrate such possibilities. We expect that as airships integrate into surface operations, the PRC's A2AD effort will be further alleviated by having to confront new layers of American forces. Attention of the PLA-N commanders aimed at countering airships is a focus taken away from the surface combatants themselves.

3. Take Charge and Move Out (TACAMO)

The E-6B TACAMO procedure of creating vertical antenna for VLF communications with submarine forces is greatly simplified aboard an airship. Presently the E-6B, a modified Boeing 707, proceeds from continental U.S. (CONUS) to a portion of the ocean where an American submarine is operating. Once on station, the E-6B conducts an "orbit maneuver" in order to whip a 15,000 ft tail into approximately 8,000 ft of vertical antenna. The orbit is sustained for two to three hours, and the overall mission time of the E-6B with refueling is a maximum of 72 hours including transit.[192]

Outfitting an airship such as the BDII with a VLF antenna is a simpler mode of communication with friendly

[192] Jane's Electronic Missions Aircraft, "Boeing E-6 Mercury," September 26, 2011, http://jema.janes.com/public/jema/index.hstml.

submarine forces. Operating at low speeds while at 10,000 ft of elevation, an upright, dipole, VLF antenna is achievable without an orbit maneuver. A VLF communications link, combined with an SCS operations "playbook," potentially provides the commander the means to update his subsurface forces and alter tasking as regional tensions and focal points fluctuate. This allows the subsurface warriors to run deep while still aware of operations above. Furthermore, it makes the modified Ohio class more viable for Tomahawk and special operating forces (SOF) tasking.

D. BALLOON-BORNE REPEATER

In the event of satellite denial by the PRC, legacy, beyond LOS (BLOS), RF communications are achievable via LTA methods other than airships. The Space Data Corporation (SDC) has developed a high altitude balloon capable of suspending up to 12 lbs of RF gear at elevations from 60,000 to 100,000 ft (see Figure 25). This gear can provide low bandwidth data connectivity, satellite like voice networks, and ISR (see Figure 26).[193]

[193] Jerry Quenneville, "Space Data: Near Space Communications System for Emergency Response," 2006, http://www.spacedata.net/documents/SD_WhitePaper_Mil6.pdf.

Figure 25. SDC's Ballon-borne Repeater. From[194]

The USAF contracted the SDC to develop their commercial balloon into a military RF repeater compatible platform in 2005. SDC dubbed the resulting platform *StarFighter*, which was:

> [T]ested extensively in the miltary UHF band for both voice and data transmissions. Voice testing incorporated analog and digital transmission methods, and the digital voice tests used both encrypted and unencrypted links. These tests supported ground-based users with military portable radios such as the PRC-148 and PRC-117. During a September 2007 Air Force Research Laboratory demonstration, a StarFighter payload floating around 79,000 feet above eastern New Mexico enabled communications between participants across the state. Both voice and

194 Quenneville, "Space Data," under "SkySite."

data communications were conducted via the StarFighter balloon-borne platform during the demonstration, using Thales PRC-148/MBITRs for voice, and ViaSat VDC-600 Data Controllers interfaced to Thales MBITR for data exchange.[195]

At peak elevation, StarFighter projects a 400-mile footprint and has a 12 hr battery life. When configured for UHF voice, StarFighter offers one channel dedicated to communications, and the second channel is used to command the balloon into station. Once on station however, the command channel is then available for UHF voice offering two circuits for every balloon launched. Up to four balloons are controllable by a single command station. Each balloon costs around $11,000 and their command station cost is approximately $50,000. Command stations have indefinite lifetimes, and recovered balloons can be serviced to fly repeat missions.[196]

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[195] Quenneville, "Space Data," under "StarFighter."

[196] Ibid.

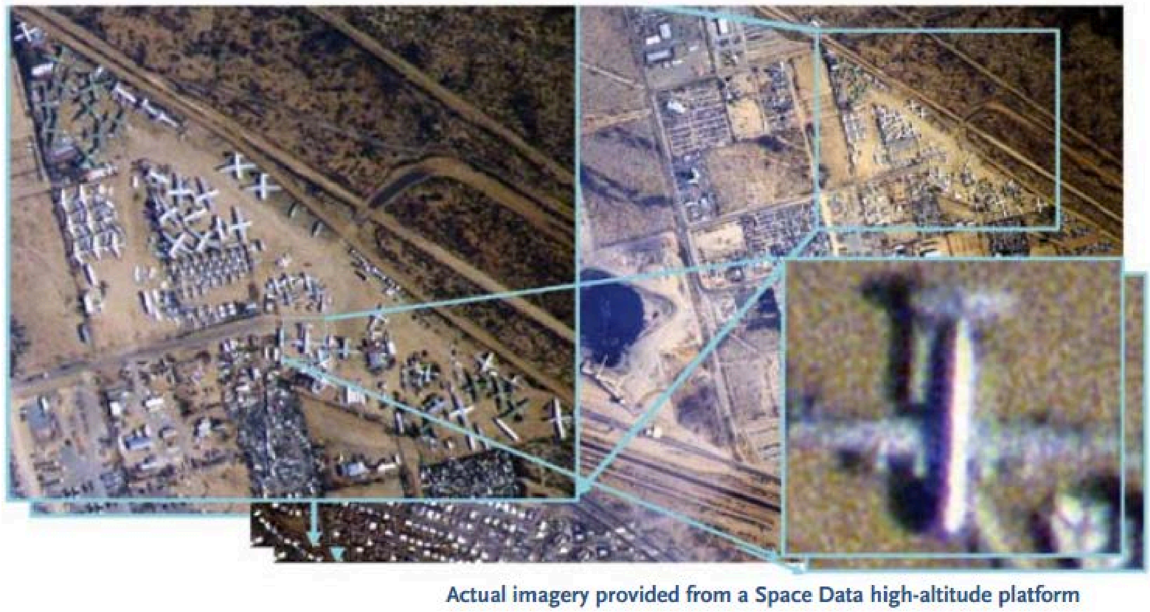

Figure 26. Ballon-borne ISR from StarFighter. From[197]

Balloon-borne repeaters also prove menacing to defeat. Targeting and killing is nearly impossible unless using a blanket method such as an EMP. In such a scenario, recovery is achieved by launching the next procession of balloons thereby making complete denial of this low cost RF strategy unlikely.

For the SCS, StarFighter, or a similar system of balloon-borne RF repeaters, offers a very attractive means to regain UHF voice and data satellite communications should the PRC effectively block or destroy the traditional paths. The major limitation to balloon-borne communications is the relatively small footprint it offers preventing the capability of theater wide communication on a common net via a single balloon. However, the potential to mesh areas

[197] Quenneville, "Space Data," under "StarFighter."

of coverage into a common voice circuit arises with geographic distribution of ships, command stations, and perhaps covert repeaters spread throughout the remote islands of the SCS. Larger and more sophisticated payloads are potentially deployable onto balloons with improved lift capacity. An advanced balloon-borne system could potentially offer inter-balloon communications via similar methods discussed for airships or presently used by satellites.

Regardless, StarFighter allows SAGs continued use of "satellite" UHF command circuits if satellites are no longer an option. In addition to providing needed redundancy to HF circuits thereby overcoming high susceptibility to jamming, balloon-borne UHF allows the SAGs the advantage of operating via its more familiar and rehearsed method of covered UHF voice circuits. Familiarity of course can reduce the fog of war.

E. CONCLUSIONS

BDII is a known entity that is presently adaptable to serve in a satellite-type function. Furthermore, the real time COP and high-speed communications offered by the airship constellation are invaluable. When compared to HTA alternatives, airship technology reduces fuel consumption, and developmental costs, while improving on station time endurance. The culmination of such factors into a single C4ISR platform deployable to the potentially satellite denied environment of the SCS ought to draw considerable Navy attention.

Airships also expand overall fleet numbers at modest cost, and complicate A2AD for the PRC. Chinese planners will have to overcome LTA sensors to better hide the movement and actions of their forces. Should the PRC decide to free themselves of the LTA network, strikes at an airship remove ROE limitations on U.S. surface forces.

An LTA constellation provides an air-gapped TAN for the MOC reducing risk on operational security (OPSEC) imposed by PRC cyber forces. Additionally, an SCS playbook combined with airship VLF antenna provides the MOC a means to update his subsurface forces.

Airships can also offer critical air early warning for the Aegis weapon system. An LTA outfitted with high fidelity radar and SM-2 illuminators can push the missile threat further away from the heart of the SAG. Such an airship offers renewed confidence and application of DDGs, CGs, and CVNs in the low flyer threat environment.

With ballon-borne repeaters, PRC denial of U.S. UHF voice and data links is temporary at best. The familiarity of satellite voice nets for the tactical watchstander in the SAG reduces the fog of war.

LTA demands attention in these trying times of increased PRC threat, and decreased budgets. Airships are a proven technology that can best serve the USN if operated by crews, at lower altitudes, and outfitted with already developed C4ISR equipment so as to guard against program deadly requirements growth. Airships have served the nation before and can do so again.

IV. CONCLUSION

> The special value of a more distributed capability achieved by greater numbers can be shown mathematically and operationally. Mathematically, it has been proven that if an enemy has twice as many ships attacking, then in an exchange of fire, the other fleet to achieve parity in losses must have twice the offensive power, twice the defensive power, and twice the staying power. The operational insight comes from observing that when a ship is put out of action it loses all three of its combat properties—offensive, defensive, and staying power—simultaneously. It cannot be emphasized too strongly that delivering a first unanswered salvo is the best tactic when it can be achieved.[198]

American surface forces have not engaged in true fleet on fleet action since World War II, and naval preparedness for such action has notably withered since the closing of the Cold War. As then Secretary of the Navy John F. Lehman, Jr. noted the USN approaches a low in the surface force level not seen since the 1930s.[199] In this naval missile warfare era, the Hughes missile salvo equation focuses the minds of naval strategists to the key elements of success: fleet numbers, staying power, scouting, targeting, and above all else *effectively* striking first. Understanding the imposed restrictions of ROE on the U.S. surface forces, Hughes' elements of success are even more critical.

The SCS scenario presents true challenges to American survival in terms of fleet numbers. The Chinese Houbei

[198] Hughes, "New Navy Fighting Machine," 46.

[199] Kinney, "U.S. Engagement Strategy," under "Little more than 13 years ago."

warship alone will constitute 100 enemy missile combatants in the PLA-N inventory. The NNFM study demonstrates how at the present SCN budgets, American missile combatant numbers can increase and approach parity with the PLA-N. The NNFM combined presence of both missile and non-missile vessels achieve a 2:1 USN to PLA-N ratio and muddle the effectiveness of Chinese missile targeting. The authors depart slightly from the NNFM study and recommend that all commissioned USN ships carry at least six SSMs. Outfitting all vessels, even patrol sized ships, with missiles makes that combatant relevant in the "missile era." Historical numbers reveal that approximately one in three missiles fired at an opponent are successful.[200] With at least six SSMs, even the smallest USN warship can reasonably kill two enemy vessels thereby contributing greatly in the factors of modern naval warfare.

Further complicating targeting for PRC ASCMs are the NNFM fleet USVs, and naval obscurant strategies. Both exploit the shortcomings of Chinese ASCM RCS based terminal homing. Any further USV development must include the ASCM decoy role achieved by increasing the USV's radar reflectivity. With USVs functioning as communications nodes, new EMCON procedures are obtainable as well. This reduces PRC scouting effectiveness while increasing the tactical viability of the American SAG commander. Additionally, combining American smoke screen tactics from World War II with modern radar obscurant technologies creates soft-kill techniques viable for present day SCS

[200] As examined in I.C.1.

operations. With these modern obscurants and obscurant delivery vehicles already developed and available, the USN ought to quickly transpose those capabilities onto the SUW community.

The big player in these findings is the airship, which dramatically improves all facets of naval warfare. Airships increase overall fleet numbers. Their constellation provides theater-wide scouting, targeting, and networking. In networking, the airship improves OPSEC for the MOC, delivers VLF communications to the subsurface assets, and provides SA for the surface group commander while his ships proceed at EMCON. An Aegis airborne adjunct extends the SM-2 engagement window BLOS improving staying power of the DDG/CG SAGs, as well as increasing Aegis' overall potential use in the highly contentious SCS. Airships also serve as a war warning, noting that the PRC will most likely strike at the constellation prior to any attacks on U.S. surface groups. A war warning facilitates an effective American first strike and achieves the paramount maxim of naval warfare. In short, the airship increases CT, increases scouting, increases fleet numbers, and reduces PRC first strike effectiveness. All of our research leads us to conclude that no single asset raises America's fortune in the SCS scenario more than the C4ISR airship. It is strongly recommended that the DoN pursue a manned airship fleet, outfitted with current DoD C4ISR gear (adding optical nodes when the technology matures), in order to provide this critical asset to the combatants.

This NNFM is an agile fleet, able to answer the risks of war, and crafted under the tenants of the present warfare age. This NNFM can defeat China's A2AD in the SCS.

V. RECOMMENDATION FOR FUTURE RESEARCH

A fruitful area for further research would be to examine a USN fleet specific C4ISR airship. Such a study should determine what present day communications and surveillance gear should go onto an airship thereby enumerating overall mission package weight, cost, and endurance.

A rewarding endeavor might also be found in contacting USAF laboratory and create a sea surface-to-air FALCON link. Such research could reveal any potential problems with locating laser based communications nodes aboard surface vessels. Additional areas of interest might be the effects of salt buildup on transceiver protective covering.

Another thesis might examine the terrestrial environment of the SCS in order to recommend locations for RF or cellular phone repeaters for a tactical network.

Lastly, an airship with its scalable size and power supply might prove to be an incredible platform for electronic jamming. A thesis investigating an LTA EW jammer is highly recommended.

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