A2AD
AND THE NAVAL ENTERPRISE

CONSIDERATIONS FOR NAWCAD 2.0

Anti-Access Area-Denial (A2AD) is a counter-measure to the U.S. imperative of access and maneuverability in the commons. In context, A2AD responses can be adopted and adapted in many ways by rising nation states wishing to support and defend their national interest. A2AD capabilities are now visible in the Pacific with the advent of unmanned systems, hypersonics, stealth aircraft and submarines, smart mines, and long-range missile systems. These technologies underscore the need for robust and resilient plans – for the U.S. Navy and its supporting institutions.

This study was commissioned by the Naval Air Warfare Center, Aircraft Division (NAWCAD) to help shape a strategy for NAWCAD 2.0 using the general context of A2AD. Insights were developed by examining military scenarios and economic comparisons, with due regard to history, technology and the Naval enterprise itself. In turn, several recommendations were made for NAWCAD and other similar institutions, to increase the responsiveness of their decision support environments and hone their ability to adapt quickly to any eventuality.

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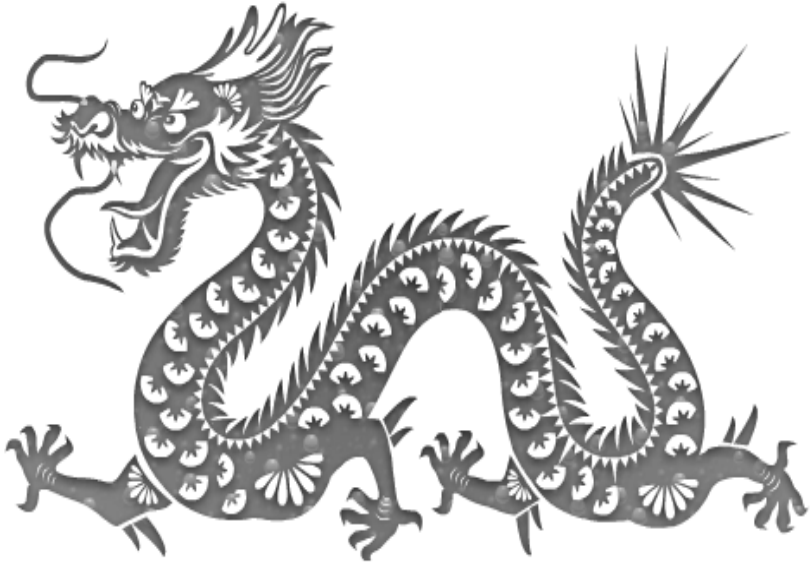

A2AD
and the
Naval Enterprise

Considerations for NAWCAD 2.0

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DEDICATED TO

The men and women of NAVAIR (the U.S. Navy's Air Systems Command), including those serving the Naval Air Warfare Center, Aircraft Division, Patuxent River, MD.

May the accumulation of information and insights in this publication serve to inspire you to advance your thinking and engage leadership with your thoughts and considerations on national security affairs. Your ideas and voice are needed.

In addition this publication is dedicated to the men and women of the Armed Services, and in particular the U.S. Navy, who remain vigilant and forward, ever present, ever ready to serve as required.

Abstract

One of the most valuable methods of strategic thinking for the 21st century comes from strategic scenario planning. The emergence of insights from game-play is one of the most novel methods of developing foresight - including feasible and pragmatic options that navigate volatile, uncertain, and complex times. In fact, insights gained from scenario planning are the basis of vital preparations for the agile and adaptive organization of the future – where the art of examining the set of "adjacent possibilities" may orient decision makers in a way that no other method can approach. This method is examined for use by U.S. Naval institutions looking to form intelligent strategies and positions for the future.

One would be hard pressed to find a more volatile, uncertain, complex and adaptive (VUCA) scenario than that which is presented to our nation and specifically the Department of Defense (DoD) by Anti-Access Area Denial (A2AD). In simple terms, A2AD is clearly a counter-measure to the U.S. operational imperative of access. A2AD represents a framework for thinking about avenues of U.S. national security response when any would-be adversary sets geographic and situational conditions that offset U.S. freedom of action in the global commons. An A2AD construct presents a context that highlights viable and antagonistic counter-intervention strategies that an adversary might use in pursuit of their national will, which may be in direct conflict with U.S. interests or U.S. armed forces operating forward.

The U.S. Navy has a clear national security mandate and operates at the vigilant forefront of any A2AD response. The U.S. Navy must grapple with the intricacies of such scenarios in advance, should they be called to action to preserve freedom of action and operations in the face of any A2AD plan. Strategic and operational change can have a tail-whip effect on the institutions that support the U.S. Navy, especially considering priorities often emerge in the moment of national need that find the institution unprepared to support with haste. Therefore, A2AD scenarios have certain implications for the Naval Enterprise, and can be used as a significant planning tool for such institutions as the Naval Air enterprise, which is a key component and a vital enabler of any forward DoD strategy.

The Department of Defense considers modeling and simulation, war-games, table-top scenarios and a multitude of scenario responses when devising operational concepts and plans. One goal is to ensure relevance of current doctrine and its application to operational scales. The Naval Aviation enterprise can leverage this same strategic thinking to develop similar responses and adequately prepare the institution to support a multitude of national security endeavors with a comprehensive and flexible risk management approach to operations, investments, infrastructure, research and development, and of course, acquisitions.

This study was conducted for the Naval Air Warfare Center Aircraft Division, where the Energetics Technology Center completed research that exposed not only the context, history and possibilities with respect to A2AD planning, but current attitudes, perceptions and beliefs of key strategic stakeholders of the enterprise itself. It included novel insights from the examination of the microeconomics of A2AD vis-à-vis China, and the impact of macroeconomics on A2AD strategies, and the confluence of technology and military application. The study provides technological preparation recommendations, and a perspective on how future modeling and simulation endeavors can enhance understanding for future decision making. This report highlights how exploration of high-risk scenarios can yield strategic insights and foresight for future planning - for the Naval enterprise, for U.S. Naval aviation and for our nation.

Preface

An adversary's capacity to limit or disrupt the U.S. military's ability to locate and operate within foreign theaters is vital to understand. In this regard, Anti-Access Area-Denial (A2AD) scenarios have U.S. strategists concerned over an array of threatening possibilities. While the U.S. military possesses the wherewithal and position to conquer opposing military conventional force-on-force measures today, it is clear based on many writings on the subject of A2AD that the U.S. would be extremely challenged by many of these scenarios in the future. Adding to the dilemma is the fact that U.S. expeditionary forces have come to rely and depend on the ability to safely gain access and maneuver in theater at operational scales, largely due to unfettered access at-scale for over 70 years since the days of the World War II and the relative ease of maneuvering in foreign waters hence. In this sense, A2AD counter-measures represent a heightened threat to U.S. national security.

While the United States continues to have a purposeful "forward presence" abroad, it is largely backed by the U.S. Navy that has operated abroad since its inception. There are subtle indicators that the risk calculus of encountering A2AD applications is changing in terms of likelihood and severity, especially for the U.S. Navy who along with the Air Force, would be "on the point" in the majority of initial and subsequent A2AD circumstances. These risks can be examined systematically. In fact, risk can be unraveled systematically AND contextually at many levels beyond grand-strategic or even warfare planning levels. Risk is of course examined by strategic military planners; however it should also be examined by the U.S. naval enterprise. Institutions that have to support war-fighting, such as the Naval Air Systems Command (NAVAIR) and one of its organizations, the Naval Air Warfare Center Aircraft Division (NAWCAD), stand to gain considerable advantage from such an examination.

Research, game-play and analyses can all be accomplished prior to the manifestation of contingencies, and should be developed more fully for the naval enterprise if a nation is to be prepared and poised with A2AD-related counter-strategies and adaptations for their enterprises, should A2AD scenarios be encountered in an uncertain future. When completed in a comprehensive manner, the institutions of the U.S. Navy stand to gain a considerable perspective on positioning, aiding and

supporting U.S. military readiness by becoming agile, learning organizations with change management strategies built-in. In this light, the U.S. Navy and its institutions such as NAVAIR and NAWCAD will stand ready to adapt from a position formulated in preparation of U.S. national security possibilities with comprehensive technical strategies that serve to address any such dilemmas like A2AD contingencies abroad.

It should be noted that "A2AD made manifest," represents *major combat operations*: A2AD concepts, games and table-top explorations call into question the capacity of the U.S. military to overcome A2AD threats, should the U.S. military be called to act in a time of conflict. The emphasis is on the word "should," especially while the debate continues as to the question of likelihood of encountering A2AD in a conflict. It is important to understand that *risk, in terms of probability and severity of consequence is assumed for the greater part of this study*. In other words, apart from an introduction to A2AD itself, this study deals not only with the questions of "What might precipitate an A2AD scenario?" – it reflects directly on the character of the engagement assuming it is already upon us – taking the position of having assumed the scenario has occurred. This study therefore focuses on the question "What might naval institutions do about it?" which lends insight into "How does a nation prepare? (And prepare not only its forces, but also its enterprises and support institutions). Additionally, "How can its enterprise leaders test the relevant hypotheses?"

Leading missions while executing A2AD responses against adversaries employing A2AD strategies becomes the U.S. Navy's principle endeavor in the event of a near-shore or on-shore conflict abroad. Moreover, there are many today who remain unaware of A2AD or its implications for the future, or even the implications for the institutions of the Navy. The perspectives of those in the U.S. Navy's enterprise, including DoD Laboratories were compiled in this study and analyzed to decipher initial patterns in thinking on the level of a pilot study. From the integration of primary and secondary research, perspectives on change management in the face of shifting global economies and A2AD philosophies were explored for the naval institution (namely NAVAIR and the commissioners of this study, NAWCAD), in order to create real world context for institutional change management strategy. *In this light, this study may be used as a catalyst for strategic change management and future positioning, workforce*

education, debate, collaboration and other similar purposes. The hope of the research team is to aid leadership in an effort to begin to uncover unique and innovative solutions for naval institutions.

A2AD thinking was initially explored through an economic context, to add a multi-dimensional lens to the discussion – one that reveals potential shortfalls and opportunities in terms of broader, "whole-of-government" thinking, to advance A2AD preparations and readiness. Micro- and Macro-economic elements of power and their relationship to historical perspectives on A2AD were explored, with a special focus on the Pacific and China. This backdrop sets a unique stage for examination of the Pentagon's recent "Shift to the Pacific" for force readiness. For example, from economic, military and technological contextual standpoints, strengths, weaknesses, opportunities and threats readily emerge in this examination. They set context for A2AD understanding for the institutions tasked to support a "pivot to the Pacific."

In this regard, when considering A2AD scenarios, China presents one of the most substantial military challenges for military planners and support institutions of DoD. For example, China maintains the capacity for a robust, layered A2AD encounter in the Western Pacific. To what end? China continues to invest in defense, as the world's second-largest economy assists in that regard. Continuous uncertainties as to the purposes for China's expanded defense budget continue to cause concern for the United States and its allies. China's lack of transparency corresponding to its defense expenditures reinforces U.S. requirements for awareness and preparedness, emphasizing importance for additional economic studies and examination of historic economic precedents and antecedents to conflict. It is also noteworthy that China represents only one strategic concern for the U.S. in light of the Pentagon's shifted focus to the Pacific. In this regard, the confluence of economic, military and technological strategic factors are useful to establish context for a broader global national security perspective noting that A2AD thinking can be exported even more easily than A2AD weaponry.

Potential adversaries of the U.S. recognize the convergence of military and technological advantages that the U.S. presents when troops are allowed to arrive at scale and on time with a technologically formidable kit. However, given a technological advantaged U.S. Navy for example, A2AD preparations can impede or even cripple conventional logistics; they can limit the scale and extent of potential use and adjustments

through a layered approach to slowing or reducing deployment (and employment) in a theater. The prevention or even interruption of entry and maneuverability can cause an inferior distant operation. For A2AD scenario planning purposes, China represents a highly adaptive adversary in this respect. For example, the rise of important economic and political centers in China's coastal region has caused a major shift in military strategy by the Chinese People's Liberation Army (PLA). PLA strategists recognize the need for highly mobile, lethal, and resource concentrated technological conditions. An updated Chinese strategy is designed to maximize strengths and create opportunities to exploit oppositional weaknesses. In this context, Chinese writings are emphatic in showing the necessity of "gaining mastery by striking first." Positioning and preparing capable and mobile assets assists this A2AD strategy. These are all reasons that the risk factor is slowly being elevated in the Pacific, contributing to a concern for the U.S. This risk permeates "economically" as well as "technologically" and "operationally." These factors are explored in this study. In kind, these factors have critical implications for naval warfare centers such as NAWCAD.

The exploration of A2AD scenarios facilitates the examination of global A2AD readiness. For example, Chinese A2AD solutions like missile systems, smart mines, unmanned systems and laser weapons, can also be exported, creating greater and more diverse global security concerns, especially for allies of the U.S. around the Pacific. Additionally, exported A2AD related strategies may also serve to affect naval resources from arriving and operating in the global commons in many key areas of the world under other-than-conflict conditions. In the event of conflict, A2AD objectives can escalate quickly and range from hindered expansion of forces in strategic forward-locations as accomplished through arrested logistics, command and control, and even degraded basing or air operations. In this respect, global technological exports can sum to Chinese advantage and may even signal the propensity of political agendas that attempt to dissuade or deter the U.S. from achieving national objectives in targeted parts of the world beyond the Pacific. In fact, Chinese writings do not speak of A2AD. Some translate to "counter-intervention" strategies, which include premeditated location, timing and temporal elements by the very definition. In sum, exported foreign military capabilities tied to specific A2AD operational measures could cause significant strain and disadvantage for the United States and also its allies, even when not at war.

Economic implications, both microeconomic and macroeconomic in scale can serve to inform A2AD offset strategies, even for the institutions that support DoD. Although the threat of A2AD strategies might be increasing, further analysis of the Chinese and U.S. defense budgets are essential to examine in order to understand financial risk. A wise defense budget analyst once remarked "show me your budget and I'll show you your priorities." The U.S. ability to address Chinese modernization efforts with deliberate military technical offsets and a combined military strategy is a successive and ongoing planning endeavor. Equal weight must be also given to the actions required of the Naval institutions that must morph to support such endeavors, including for example, the technical and organizational approaches necessary for NAVAIR and its elements such as NAWCAD to support such things as unmanned carrier aviation. Comprehending that it takes years if not decades to build effective labs, test facilities and expertise for new technologies, time is of the essence in defining readiness requirements.

Understanding the various comparisons and implications of U.S. allotments of resources (especially with respect to a Chinese defense budget) allows U.S. analysts to gain perspective on advancing efforts in innovation, ways to heighten efficacy of worthy programs, means to ensure technical balance, and ways to advance institutional preparations. Today, these assessments may serve to mitigate the erosion of purchasing power parity from levels that might mortgage future U.S. advantages. In contrast, the U.S. might react differently if the increasing Chinese defense preparations were due to vast accumulation of funds in healthcare, salary, and retirement instead of A2AD capabilities. Assessments, comparisons and evaluations using future forecasting models and simulations are possible. Rendering a budget breakdown, utilizing trends, and assessing purchasing power parity conversion factors are fundamentals of such efforts, and provide a strong foundation for understanding Chinese defense trends and their corresponding influence on A2AD capabilities and capacities. Many of the examinations are included in this study and begin to aid leadership in avoiding strategic traps and pitfalls, while setting future possibilities for assessment capabilities and opportunities for NAVAIR, NAWCAD and others. Several models, frameworks, and tools for this type of advanced decision making environment are offered in exploration of the A2AD topic. In the end, the introduction of these tools will enhance decision making at all levels.

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In particular, Dr. Dale Moore and Dr. Eui Lee of the NAWCAD Strategic Cell were instrumental in initiation and collaboration during this research. They provided access and connections to leadership. It was apparent to the research team that these professionals are dedicated to strategic thinking and thought-leadership, which is in keeping with the highest ideals of national service. Their exhaustive efforts and dedication are not unlike many NAWCAD professionals, as they continue to support leadership with recommendations for quality decision making in a multitude of future scenarios like A2AD. Ultimately their insights and foresight have substantially influenced our thinking and our work. Their efforts are applauded, acknowledged and appreciated by the ETC research team.

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Author Biographies

Mr. Keith Gordon is a retired Naval Aviator and Senior Program Manager currently serving as ETC Director of Strategy and Innovation. At ETC, Keith also serves as Director of TechFire, Southern Maryland's only technology business incubator. Prior to taking this position, Keith retired from active duty after a 20+ year career in the U.S. Navy, having worked directly for the Chief of Naval Operations (CNO) as a Senior Technology Fellow. In this role, he served in a highly innovative and collaborative think tank called the Strategic Studies Group, where he was a designer for the U.S. Navy-after-next. At SSG, he led the war-gaming of scenarios like A2AD and was responsible for generating revolutionary naval warfare concepts in order to ensure future relevance for the U.S. Navy. During his Fleet service and multiple ship deployments around the world, he accumulated over 3500 hours of flight time with over 2250 hours in SH-60B helicopters, including over 1000 hours of fixed wing flight instructor time in the T-34. Mr. Gordon has a Bachelors of Science in Physical Oceanography from the U.S. Naval Academy, and two Master of Science degrees from Embry Riddle University in Aerospace Management and Aviation Safety Systems Engineering, where he graduated with distinction. He is also a graduate of the U.S. Naval War College, earning a Master of Arts in National Security and Strategic Studies. He is currently an MBA candidate at John Hopkins University while pursuing an MA in Design Leadership from our nation's oldest art college, the Maryland Institute College of Art.

Mr. Robert Kavetsky is the President and Executive Director of ETC. ETC develops technology-focused solutions for a number of DoD clients, as well as providing policy development for local, state and federal agencies. During his 32 year career in the Department of the Navy he designed and operated hypersonic wind tunnels, and led programs and organizations in undersea weapons and mine warfare. In 2002 he was appointed the first Warfare Center Liaison to the Office of Naval Research where he established the N-STAR program, a Navy-wide effort aimed at reinvigorating the science and technology community within the Navy's Warfare Centers. Mr. Kavetsky received B.S. and M.S. degrees in Mechanical Engineering and a Master of Science degree in Engineering Administration from Catholic University. He has co-authored 9 books, on topics including perspectives on

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Dr. Marcus Jones is professor of economic and military history at the U.S. Naval Academy and the author/editor of monographic studies on German economic mobilization in the Second World War, the history of naval technology, and the American way of war, as well as scholarship on the strategic history of the Prusso-German Kaiserreich and a four-volume encyclopedia of German military history. Dr. Jones took his PhD from Yale University in 2005. He lives in Annapolis, MD.

Dr. Elan Moritz is ETC's chief scientist. His research interests include high level systems analysis, simulations, and assessment of complex and nonlinear systems, cognitive computing, and 40 years of high technology development and leadership experience. His 30 year career at the Naval Surface Warfare Center, Panama City Division included directing the Navy's exploratory development research program in sonar and torpedo countermeasures, heading the signal and image processing branch, directing the commands' modeling and simulation office, and leading technology efforts associated with unmanned systems and with electro-optic sensors. His career with the Department of the Navy also included an assignment at OPNAV as Technical Director- Mine Warfare. Prior to his Navy career, he was a nuclear safety analyst at EBASCO Services in NYC where he participated in the design of the Tokomak Fusion Test Reactor for Princeton University, and in design and evaluation of several commercial nuclear power plants. Dr. Moritz is the author of papers and technical report in various areas; he holds 14 U.S. patents in areas including counterterrorism, cybersecurity, unmanned systems, and smart containers (mission modules). A number of systems conceived and developed by Dr. Moritz are now in RDT&E acquisition and in fleet use. Dr. Moritz earned his Ph.D. in Physics from Kent State University, and a B.S. in Physics from the State University of New York at Stony Brook.

Mr. Billy Clark is a student at the University of Alabama, studying Chemical Engineering. His research efforts are noteworthy as he completed an internship with NAWCAD, where he completed much of the critical background studies for Chapter 2 of this report.

Acronyms

A2AD	Anti-Access/Area Denial
AAM	Air-to-Air Missile
ACE	Assessment and Concept Evaluation (Tool)
ASBM	Anti-Ship Ballistic Missile
ASCC	Anti-Ship Cruise Missile
ATSC	Air Tactical Service Command
BAA	Broad Agency Announcement
C2	Command and Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
CV	Aircraft Carrier
CVN	Nuclear Aircraft Carrier
DARPA	Defense Advanced Research Project Agency
DoD	Department of Defense
DOE	Department of Energy
DON	Department of the Navy
ETC	Energetics Technology Center
EW	Electronic Warfare
FFRDCs	Federally-Funded Research and Development Centers
GAO	Government Accountability Office
GDP	Gross Domestic Product
HAE-UAV	High Altitude Endurance Unmanned Aerial Vehicle
IED	Improvised Explosive Device
IISS	International Institute for Strategic Studies
JDAM	Joint Direct Attack Munition
JOAC	Joint Operational Access Concept
JP-5	Joint Operation Planning
LDRD	Laboratory Direct Research and Development
LRRDPP	Long Range Research and Development Planning Program

M&S	Modeling and Simulation
MMOWGLI	Massive Multiplayer Online War Game Leveraging the Internet
MTR	Military Technical Revolution
NA	Net Assessment
NAE	Naval Aviation Enterprise
NAVAIR	Naval Air Systems Command
NAVSEA	
NAWCAD	Naval Air Warfare Center Aircraft Division
NWRL	Nuclear Weapons Ready to Launch
OECD	Organization for Economic Cooperation and Development
ONR	Office of Naval Research
OODA	Observe, Orient, Decide, Act
PAC-3	Patriot Advanced Capability-3
PACOM	U.S. Pacific Command
PCC	Chinese Communist Party
PEO	Program Executive Office
PGSM	Precision Guided Sub-munitions
PIA	Partnership Intermediary Agreement
PLA	People's Liberation Army
Pk	Probability of Kill
PPP	Purchasing Power Parity
PRC	People's Republic of China
R&D	Research and Development
RMA	Revolution in Military Affairs
RNA	Retrospective Net Assessment
S&T	Science and Technology
SAM	Surface-to-Air Missile
SIPRI	Stockholm International Peace Research Institute
SOS	Systems of Systems
SPAWAR	Space and Naval Warfare Systems Command
STEM	Science, Technology, Engineering, and Mathematics
TD	Technical Director
UARCs	University Affiliated Research Center

UAV	Unmanned Aerial Vehicle
VUCA	Volatile, Uncertain, Complex and Adaptive

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Executive Summary

Background: The confluence of worldwide economic, technological, and military strategies in support of A2AD results in a changing risk calculus for the U.S. These factors also challenge the Department of Defense, and all its institutions, including the U.S Navy and organizations such as NAVAIR and NAWCAD. A2AD is one type of strategic planning scenario that represents potential significant risk in the form of stress and strain to these institutions.

Examining A2AD scenarios from the combination of economic, technological and military angles creates unique context to understand the problem of A2AD. This union of factors underscores the value of understanding A2AD in terms of: supply and demand; counter-A2AD capacities and risk; and A2AD decision making environments and institutional readiness. This study explores the intersection of these elements to aid an 'enterprise-wide' understanding to learn, to devise innovative solutions to future threats, and to create operational opportunities for war-fighting and institutional advantages alike.

NAWCAD, for example, is an institutional exemplar in this regard. NAWCAD has researched, developed, tested, and supported Naval Aviation and U.S. power projection capability developments for decades in direct support of U.S. national security. However, the realization of the changing risk calculus as presented by such scenarios as A2AD, requires NAWCAD to adapt. They must create or adopt change management strategies to advance their credibility and capability as an institution ready and prepared to support national security endeavors with power projection and sustainment capabilities for possible major combat operations associated with counter-A2AD. The alternative is to suffer the fate of irrelevancy. This study notes that NAWCAD is not the only institution that stands to gain from considering its position relative to high-end challenges such as A2AD. Just as U.S. military planners achieve a heightened state of readiness by grappling with strategic questions through the use of strategic scenario planning – so too can institutions such as NAWCAD. When engaged proactively through enlightened strategic planning, a new generation of innovative solutions and foresight will follow. This applies for both technological endeavors of the fleet, and also strategic positioning of the enterprises which

support the fleet. U.S. Naval Aviation in turn has been a cornerstone of U.S. military contingency response and has faithfully discharged duties in support of U.S. national security endeavors for over a century. This study offers several unique contributions to institutional war-fighting readiness preparations and thinking, in order to support forward-leaning institutions such as NAWCAD to sustain this edge and meet future objectives efficiently but more importantly, effectively.

Discussion: This study specifically offers:

(1) A2AD reflections from historic, technological and economic perspectives to set context for the naval institution;
(2) concerns, insights and foresight garnered from 20 key interviews of representative institutional leaders from within the DoD enterprise;
(3) implications and opportunities, particularly for NAWCAD, to inspire thoughtful leadership and drive an examination of the possibilities for strategic change management and transformation to a "NAWCAD 2.0", which is defined. (This can be accomplished in part through the development of decision support environments using comparative assessment and evaluation tools like ACE (Assessment and Concept Evaluation Tools) that aid in planning and positioning for the future. These tool sets can be designed to conduct comparisons and assessments that derive novel perspectives by compiling and analyzing many key reports, surveys, games, concepts and perspectives – yet to be compiled – which currently exist inside and outside of the Naval enterprise);
(4) recommendations for a way forward to bring these ideas and tools to the benefit of naval aviation. The recommendations are oriented to raise understanding of situations such as A2AD, as an institutional issue as well as a war-fighting issue, in order to guide strategic convergence, cohesion and planning efforts. Ultimately, the goal is to improve the readiness of the entire naval air force and the network that supports it, enhancing national security in the process.

Results: The U.S. Navy is continuing to operate forward and near foreign waters. A2AD has been assessed as both a stressful and important analysis for U.S. national security. Risk of A2AD scenarios is defined in this report in terms of increasing likelihood and high-consequence if occuring. The likelihood that U.S. forces will encounter

either A2AD scenarios or weapons built in support of A2AD measures is increasing. Risk exists to U.S. forces, yet, institutional and enterprise risk is also being unwittingly assumed due to the lack of full understanding of A2AD conflict implications. For example, exported A2AD technologies, systems, and strategies coupled with counter-intervention plans question not only U.S. operational positions, but also U.S. technical preparations and U.S. enterprise readiness to adapt to theater-wide crises. The acquisition and institutional focus on large programs of record and cost-schedule-performance measures leaves questions of credibility in creative adaptation, speed of discovery and ultimately innovative capacity of U.S. naval institutions.

Implications: In summary, A2AD scenarios represent increasing risk for the institutions of the U.S Navy, just as they do for U.S. Forces in general. The confluence of national and international economic, technological, and military trends elevates this risk. A2AD as a large-scale problem is presented in scenario format as a highly technological, interfaced, networked and contested arena. The weight of the endeavor calls for the institutions of the U.S. to form a weighted approach to unraveling the associated complexity. Future examinations and context for A2AD scenarios can be developed in highly iterative and exploratory processes for decision making and learning. For example, assessments, reports, war-games, real-world events and even professional perspectives can be assembled, compared and analyzed in a reasonable and thoughtful manner via deliberate tools, some of which are highlighted in this report. A unique capability ETC has termed ACE – Assessment and Concept Evaluation – is one example of a tool that supports a robust decision making environment of the future using cutting-edge data analytics, literature-based discovery algorithms, and advanced modeling and simulation capabilities. More importantly, there are ways to use complexity science, network theory, data analytics, discovery algorithms, software fusion engines and supercomputing hardware to collect, compile, summarize, contrast and analyze very disparate information and sources, including the structured and unstructured data sets that surround A2AD. Tools such as ACE can perform surprising analytics at scale for affordable costs which has the capacity to greatly enhance and synchronize decision making efforts at all levels, and across the institution. After conducting this study, it is the opinion of the authors that the U.S. Navy and its support institutions such as NAVAIR and NAWCAD would benefit greatly in actively obtaining these analytic capabilities to assume the roles of “learning organizations” who

challenge all technical assumptions and remain proactive with change management strategies when new information is available. This mitigates risk in the future via tools and professionals who assist one another in ensuring a robust national security posture.

Structure of this Study

Each chapter of this study was written to stand alone. Together they form a unique picture for NAWCAD with respect to planning considerations in the A2AD domain – with implications for NAVAIR, NAWCAD and the Naval enterprise. For example, from insights at the convergence of economics, technology and military endeavors, technological purchase by world superpowers is seen in context via first-order analyses.

Technical insights have even greater merit when considered in an A2AD context with respect to the institutions that are developing them, whether intent is use, deterrence or sale. Additionally, these technologies can be considered in conjunction with historical perspectives on A2AD, and the military tactical scenarios for which they might be developed. In this respect, A2AD is used as an example, vis-à-vis China.

The structure of this study is as follows:

Chapter 1: A2AD primer, and Counter-Intervention Strategic Background, with introduction of the Problem Statement. This chapter frames definitions of A2AD, the strategic significance of A2AD scenario planning and highlights hypothetical risk analysis from the perspective of shifting A2AD likelihood, and the severity of potential outcomes.

Chapter 2: Economic Context: A2AD / Counter-Intervention Microeconomic Analyses. This chapter frames some tactical and operational comparisons with economic assessments in financial terms.

- A2AD grand strategy examples (China); capabilities & cost
- U.S. Capabilities and cost
- Comparisons and Analyses (U.S. strategic economic considerations, if called to act in the near future)

Chapter 3: Strategic and Historical Context: Historical A2AD / Counter Intervention and grand strategic thinking, with historical and macroeconomic, state-level, industrial foundations in relation to an A2AD scenario with China.

- Historic and Macro-economic context for the Contemporary Chinese A2AD challenge
- The use and limitations of history in A2AD analyses
- An in-depth historical case – Japan in the Interwar Era (Pre-WWII Japanese expansion case studies, critical considerations)
- Reasoning from the Historical Case Study to China today. How case studies influence preparations in one way or another (For the U.S., for U.S. Navy, for Naval Aviation, and potentially for NAVAIR)

Chapter 4: Strategic Scenario Planning and development of A2AD scenarios with technical and military context developed.

Chapter 5: Stakeholder Perceptions and implications from key institutional leaders on dimensions of A2AD Scenarios and the Naval Enterprise.

Chapter 6: Naval Aviation implications and NAVAIR Organizational Considerations from A2AD analyses. Thoughts on a "NAWCAD 2.0."

NOTE: Chapters 5 and 6 are devoted to possibilities and opportunities based on analyses. They are designed to aid understanding, encourage participation in strategy formulation and elevate awareness for a technological-advantaged future that includes strategic A2AD counter-technology refinements and change management transitions for NAWCAD. This report reflects the concerns of those in the warfare centers for the need of models for technological change management and enterprise learning that revolves around valuable assessments and thoughtful approaches, including the challenges of A2AD.

Chapter 7: Comments on Assessment, Analysis and Evaluation Tools for Future A2AD scenarios, including the development of an ACE Tool.

Chapter 8: Recommendations and Conclusion. (How NAVAIR / NAWCAD can look at the problem and diversify options)

References: Current A2AD Bibliography and Appendices.

NOTE: The discussion of A2AD scenarios, comparative assessments and future possibilities is the goal. Stressful scenarios challenge institutional culture, norms, biases and expectations. They inspire insights for the purpose of formulating robust and resilient perspectives and foresight. A good look at vital decision points and non-standard solutions emerges from the art of game development and game-play, which includes reflection from deliberate context and stressful scenarios. From this basis, novel constructs and actionable steps can be brought to bear thoughtfully, and can be deciphered and compared for the institutions of the U.S. Navy. These games form a larger context for scenario development as a touchstone for understanding and become a deliberate form of debate.

Several high-risk considerations are addressed in a frank manner for Naval Aviation and NAWCAD, in order to raise the level of understanding, and to inspire the crafting of additional future scenario-based planning endeavors. In turn, new context will invite participation and increased energy toward novel solutions, as problems are identified and novel solutions are examined by the stakeholders of institutions conducting the scenario planning endeavors. The ultimate goal is to assist and facilitate educated discussions and interactions within and around the Naval enterprise, in order to advance knowledge and decision making efforts from within.

This research is also offered to aid in the future design of offsetting strategies – ones that include constructs for credible deterrent options, offsets and real peace in the face of volatile, uncertain, complex and adaptive times ahead.

Chapter 1

Introduction

May we live in interesting times – or so goes the oft-repeated proverb for the ages. To anyone concerned with U.S. national security, a logical follow-on question might be "how interesting can things truly become?" Insights, opportunities and strategic foresight may arise from the exploration of this question. For the national security professional, Anti-Access/Area Denial (or A2AD) thinking represents one of the deepest explorations of this type of framework, and it is a fresh way of exploring future possibilities for DoD.

In this light, the overarching objective of this study was to raise the debate and encourage scholarly discourse on the topic of A2AD – for the ability to learn quickly is simultaneously the greatest source of U.S. strength and a vital source of U.S. adaptation. In that regard, this study was commissioned by NAWCAD, a division of NAVAIR, to research A2AD technologies, key stakeholder perceptions of the future strategic landscape with respect to A2AD technologies, and analyze A2AD scenarios for the enterprise, in order to provide specific recommendations for NAWCAD, which must position itself to support the U.S. Navy.[1]

A certain objective of this study from the outset was the rapid education of those unfamiliar with A2AD without losing an audience steeped in the subject. The objective was to invite interested parties to quickly participate in ongoing discussions while also advancing them. This study was also designed to offer novel insights in the form of primary research from first-hand interviews of DoD professional leaders who set, influence or execute DoD policy. In addition, this study was designed to provide a broad look at A2AD with depth of field for Naval Aviation and its organizational elements, but also for other services who will partner to create innovative solutions. Finally, this effort was designed to offer very current secondary research and a comprehensive set of A2AD related references.

This study offers insights on institutional perspectives and how NAVAIR and specifically NAWCAD might look at A2AD in order to anticipate change management strategies and position for the future. In turn, the goal was to inspire readers to become part of the strategic solution, and to prepare U.S. naval institutions for hurdles along the way. From whatever initial position one enters the A2AD debate, unique and challenging risk considerations help refine foresight and novel solutions

on key issues. The outline which follows offers an economic, military and technological look at A2AD as a "launch-pad" for contextual examination of the topic. It also offers analyses and recommendations that help clarify some of the ambiguous situations that surround A2AD and a comprehensive reference list on the current body of work on the subject.[2]

It is clear that the U.S. Navy will be one service on point to establish and maintain operational access in the future, should they be called to action. Simply stated, this study seeks to advance thinking and uncover new ground with respect to A2AD perspectives and philosophy – both for the novice who may be stretching into the A2AD national security scenario planning for the first time – or the seasoned national security professional looking for novel perspectives and frank discussion that includes recommendations for the Naval enterprise. In this regard, A2AD is rich in exploration opportunities as a classic VUCA scenario (Volatile, Uncertain, Complex and Adaptive situational elements). In attempting to unravel the intricacies of the scenarios, it is useful to start by defining A2AD at the outset.

Definitions

A2AD most simply stated is a ***counter-measure to the U.S. imperative of operational access***. However there are three definitions worth pursuing to enhance A2AD definitions for the future. The first is derived from a 2003 report by the Center for Strategic and Budgetary Assessments (CSBA) and is offered to highlight one American perspective that many U.S. national security professionals use to focus on the concept. CSBA defines *anti-access* as "*enemy actions which inhibit military movement into a theater of operations*", and *area-denial* operations as "activities that seek to *deny freedom of action within areas under the enemy's control*."[3] Yet, a sense of grand purpose seems to be lacking from this definition. Some analysts take a broader view of A2AD and use less U.S. focused definitions. For example, Sam Tangredi in his latest book, Anti-Access Warfare has a very solid statement of the objective of an A2AD strategy built from an historical perspective: "…*to prevent the attacker from bringing its operationally superior force into the contested region, or, to prevent the attacker from freely operating within the region [while] maximizing its combat power.*" The final definition worth considering adds a heightened sense of purpose, and is a simple but controversial definition derived and extracted from Chinese writings on the subject. Building on competitive perspectives and factoring Chinese philosophy of "*counter-intervention,*"

A2AD can be thought of as a "*scalable, counter-intervention approach*[4]" in support of national endeavors. A2AD then becomes a credible deterrent against access and an insurance policy for interference.

The differences between a U.S. approach to access and a Chinese approach to anti-access are worth mentioning. To examine carefully the notion of "intervention" or "counter-intervention," is to extract the implied idea of eliminating intrusion or intercession in one's specific affairs over a specific period of time. This idea of "protection of a properly timed strategic endeavor for a limited duration" is important to unravel. Naturally, it follows the goal is prevention of an outsider's interference. This leads to a design criteria for A2AD technology and systems as prevention mechanisms (or credible deterrent options) against those who wish to involve themselves in foreign affairs. In other words, A2AD may also be thought of as the ways and means of securing a discrete objective, by "*deterring*" or when necessary "*preventing"* any involvement over the required time to achieve and sustain a national objective.

By re-orienting the focus to a "counter-intervention" perspective, one realizes that an adversary's application of A2AD measures may be intended as range of options - from deterrence to full-scale response. The "counter-intervention" definition weights the importance of time, timing and method to the strategic goals of the implementer. By the nature of this definition, it contrasts implicitly with the U.S. naval concept of freedom of action in the commons, which relates to U.S. timing and maneuverability using any chosen method in international waters. In other words, as long as the U.S. does not interfere in a region, they may be permitted all the access and maneuver they desire.

It is for this reason that the inclusion of "counter-intervention" perspectives might further advance A2AD thinking. Hence, a deliberate examination of foreign A2AD technologies and methods can reveal clues about timing and strategy of endeavor, likelihood of interaction or friction, and an informed future notion of A2AD that might challenge current pre-planned responses.

In any event, whether A2AD is thought of as a philosophy, a planning scenario, a strategy, a hypothetical situation, a historical perspective or simply a strict military tactic, A2AD can be purposefully considered for this study as ***a set of scalable, counter-intervention measures offered in the face of the U.S. operational imperatives of access and freedom of action in the commons***.

A2AD Risk: High Consequence and Changing Likelihood

A frame of reference on what might constitute a true A2AD contest is a good place to begin. Evan Montgomery, in his current assessment "Contested Primacy in the Western Pacific," highlights the possible character of interactions of an A2AD strategic scenario with the People's Republic of China (PRC). As an example, he states:

> "A fight between the United States and China would pit a maritime power far from home against a continental power within its own neighborhood. Consequently, Washington would need to dispatch reinforcements from thousands of miles away, sustain its military units over lengthy air and sea lines of communication, and operate them from a small number of bases. Beijing, however, would be able to concentrate its forces more rapidly and support them more easily. Compounding this geographic asymmetry, the People's Republic of China (PRC) has adopted an Anti-Access/Area Denial [perspective] that could allow it to obstruct the arrival of additional military units (A2) and limit the effectiveness of forward deployed forces (AD), specifically by targeting theater bases; aircraft carrier strike groups; and command, control, computers, intelligence, surveillance, and reconnaissance (C4ISR) systems that underpin U.S. power projection. Toward this end, China has been developing and fielding a variety of advanced land-attack, sea-denial, counter-air, and counter-C4ISR capabilities, many of which could be employed from the relative safety of its own territory. Because the United States has grown accustomed to opponents that are too weak to seriously threaten its overseas bases, ([including] air and naval forces, and information networks), a confrontation with the PRC would represent a major departure from the types of conflicts it has fought and prepared for during the uni-polar era."[5]

Additionally, RAND has defined the character of a Chinese strategy which may represent the type of thinking necessary for preparations for such a conflict:

> "China's military strategy has shifted from defending the continent to defending areas on China's periphery [from] maritime force projection. Instead of fighting a 'People's

> War' involving human-wave attacks, the PLA is now preparing to fight a 'local war under high-technology conditions.' PLA strategists expect such conflicts to be characterized by limited political objectives, the use of information technology and by being highly mobile, lethal and resource intensive."[6]

Enter the realm of A2AD – from strategic security challenge to grand strategic military planning. A2AD is currently one vital area of debate that challenges national security professionals who work feverishly to characterize and understand the nature of A2AD scenarios in meaningful ways (as highlighted in the aforementioned hypothetical contest with the PRC). Unfortunately, the true ramifications of force-on-force match-ups are more highly debated in military terms than institutional terms. "What if" scenarios are rarely converted or debated at scale in strategic military translation for the enterprises of the U.S. Navy such as NAVAIR, and NAWCAD. They are rarely assessed for their impact on the institutions of the U.S. Navy itself. Yet, national security depends as much upon the industrial complex and related institutional support structures as it does upon military equipment and the troops that use the technology and equipment they are presented. The echoes from the lessons of WWII ring true in this regard.

In view of the ensuing scenarios and the potential for escalation derived from A2AD considerations, one might be convinced that these scenarios present one of the gravest threats to U.S national security. Simply calculated, threats to institutions will mean adaptation of U.S. forces and force requirements in a timely manner. In other words, A2AD scenarios have significant importance to DoD institutions such as NAVAIR and NAWCAD that will have to adapt to provide advanced capabilities in response to changing conditions. Political calculations that dismiss A2AD scenarios as unlikely often mischaracterize or under-represent the critical elements of economics and technology that might come together at once to precipitate their use. This is a cautionary tale where failure to consider possibilities is to remain ignorant of the potential of their combined ramifications for war-fighting, or to miscalculate the associated probabilities of success.

The U.S., as a world super-power, has achieved relative national prosperity. Yet, at present, the U.S. is reintegrating tens of thousands of soldiers returning from two wars, while also trying to recover from an economic recession. Moreover, in the scope of historical cycles of defense ramp-up and drawdown, the U.S. is expecting decreasing

defense budgets as part of a those cycles. In light of growing national security concerns that include terrorism, piracy, human trafficking and claims over scarce resources in waters such as the Arctic, A2AD scenarios provide another set of compelling derivatives – they set an extremely stressful context for the U.S. versus nation states that may use A2AD measures to gain advantage at a time of U.S. pre-occupation and economic adjustment. Therefore, A2AD scenarios present a special backdrop for defense planners who seek to analyze and characterize a range of high-end risk profiles for the U.S. military.

The goal of defense planners is to plan for contingencies that take into account many scenarios, in order to form a robust and resilient set of operationally sound military strategies, which can be morphed and modified to fit a plethora of world events and U.S. circumstances as they unfold in no certain order. Yet military planners should not be the only ones considering the "what-if" of A2AD possibilities. More importantly, leaders of NAVAIR and NAWCAD can anticipate future operating environments and requirements by examining A2AD scenarios for themselves.

In evaluating a national response to A2AD, it helps to define the context of the conflict for testing purposes, in order to assess a concept's robustness and resiliency. In this sense, the ambiguity surrounding the possible manifestations of high-end A2AD scenarios offers the very stress that brings out a concept's value.

The scale associated with A2AD offers overwhelming and unpredictable stressors – the type of risk that can only be defined in terms of high consequence or severity of outcome. In other words, insights and foresight are gained when one considers the difficulty of an A2AD scenario with regard to the scale of an entire theater such as the Pacific. By preparing for the worst, versus hoping for the best, one can mitigate risk through preparedness so as not to be surprised.

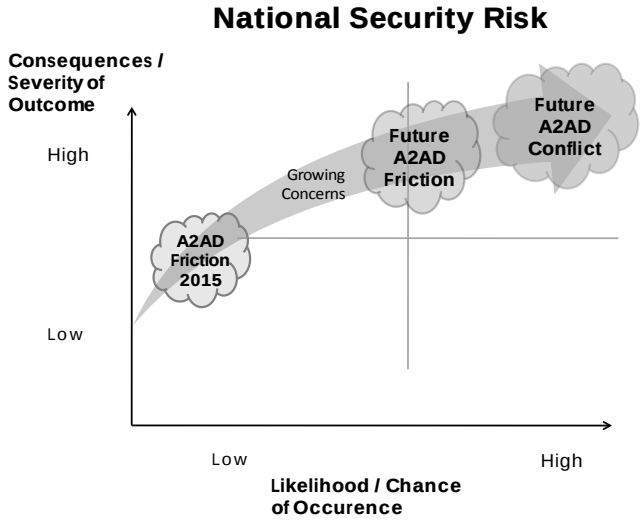

Figure 1. Categorizing National Security Risk by Likelihood and Severity

Based on the unfolding of events on the very tumultuous and tenuous world stage of the 21st century, A2AD adds uncertainty for future generations. Adding to the tension of the unknown are nations who are currently building up military power in profound ways for unstated goals and unclear desired end-states. China is not the only nation defining readiness in terms of A2AD possibilities in this regard. Many nations are thought to be adopting or co-opting portions of what the U.S. has characterized as A2AD thinking (e.g. Iran for example, has threatened denial through the closing of the Strait of Hormuz, or denied use of the commons of the Arabian Gulf).

For most national security professionals, A2AD is a tremendously useful construct for exploration – functional in its essence at all scales – tactical, operational and strategic. For example, A2AD can be addressed from the granular details of stand-off weapons such as missile systems and their possible targets of opportunity or strategic comparative assessments of capacities to act in a coordinated fashion across a theater of operations. Considerations also include the leverage provided by other U.S. forces and economies of scale, such as U.S. inter-agency capabilities and allied contributions.

A2AD scenarios offer a special brand of risk assessment for the United States. A2AD scenarios reveal 'vital' threats to foreign policy, commerce and trade, U.S. infrastructure overseas and even risk to

national security. Yet, they can give rise to a set of decision points that can be largely analyzed in advance. One can also quickly gain perspective on "lesser included" missions by assessing A2AD risk.

Risk can be defined in terms of consequence, or the potential severity of outcomes, yet risk can also be defined in terms of likelihood, in addition to severity of outcomes.[7] Yet to forgo the likelihood argument is to deliberately examine the stressful "what if" simulation. "What if" war between superpowers emerged? Given that it did emerge, how would the U.S. respond? What might the most adequate response look like? In other words, how might things play out?

Starting from the perspective of "what if" frames the initial foundations for the discussion. Starting from this "assumption of conflict" (for planning purposes only) can aid in the characterization of risk in terms of severity of A2AD encounters: it can shed light on root causes of problems which can escalate or morph into larger multi-theater conflict at multiple scales (read: limited war at scale or even unlimited warfare). In this case, speculation should include the extensions, limits, friction points and rough edges of foreign policy that might characterize the onset of conflict (and be mitigated). In this sense, learning about risks and opportunities through direct engagement is as useful for the U.S. Navy as it is for the naval institutions that support the U.S. Navy. Scenario planning is purposeful in this regard.

A2AD Primer and the Chinese A2AD Scenario: Preparation for Further Analyses

While China's strategic intentions and ambitions are unknown and unstated, they have been investing heavily in defense related activities – for decades. For example, the Wall Street Journal recently highlighted before-and-after satellite imagery of Chinese endeavors in disputed territorial reefs near the Spratly Islands in the South China Sea. These photos showed visual evidence of an artificial island the size of 14 football fields in length, with two piers and a cement plant, thought to be a part of a well-planned campaign to create "a chain of air and sea capable fortresses [for] an Air Defense Identification Zone, or [other] Chinese infrastructure explicitly military in nature."[8] To what end? The lack of transparency of Chinese strategic intentions is particularly compelling. It is worth examining in an effort to clarify A2AD possibilities and opportunities.

When a rising power (China) meets an incumbent superpower (such as the U.S.), the richness of possible friction points and escalation criteria provide depth and context for many strategic scenarios. As China invests

in what U.S. officials characterize as A2AD measures, the high-end A2AD scenarios with China take shape as a natural consequence. The 2014 Annual Report to Congress on Chinese Military and Security Developments highlights risk for the U.S. due to technological threats to U.S. forces should conflict arise in the Pacific theater. The report specifically highlights thinking that U.S. planners use to characterize an A2AD framework in the Pacific. [9] Yet, what remains most unclear is how China's technological advancements and A2AD perspectives size up relative to future U.S. military capabilities, given other global demands, if a conflict scenario were to unfold. It is useful to examine what it might look like if U.S. Naval and Air Forces are required to respond to a crisis in the western Pacific Ocean and China were to impose anti-access responses or area denial strategies. Moreover, beyond capability, it is useful to examine the true capacities for action, especially understanding the vast majority of technology will be legacy systems not designed for A2AD scenarios. What metrics does one use to size up readiness and possibilities with any relative purpose?

Metrics are difficult to develop with any certainty. For example, there are ample grounds to suspect the veracity of official Chinese facts and figures. Most analysts cannot be certain of the reports that Beijing generates for the world. For example, the question of what is actually spent on military goods and services and how spending relates to that which is acquired is unclear. There are high probabilities associated with filtering and skeptical sourcing from central party organizations. Should we evaluate China at face value? Just how much is really being disclosed, and what effect does stated financial and economic reporting have on current and future analyses and comparisons. However the art of strategic thinking is to "play" within the realm of plausible "what-if" possibilities - the factors and metrics may be more vital to consider than details. Yet, the inadequacy of data presents problems for any national security analyst seeking to weight factors and examine probabilities.

Some theorists propose that China has likely been preparing its "long-view" for over four decades, for wide-scale, theater defense with the advanced modernization reflected in its procurements. Pundits will speculate. Yet, the reality is that China continues to modernize its military and patrol well beyond its shores, while politically addressing its own growth vs. resources, allies vs. regional influence, and territorial disputes vs. control.

While objective information to aid decision makers is at a premium, technological positioning for the U.S. Navy, NAVAIR or NAWCAD in light of such an A2AD perspective can be more logically and rationally

considered, especially in the face of advancing technologies. This study seeks to challenge the current state of information and useful knowledge available in that regard.

DoD's Joint Operational Access Concept (circa 2012), lists the technological imperatives facing our nation:

> "Emerging trends in the operating environment promise to complicate the challenge of opposed access for U.S. Joint Forces: [Specifically] the dramatic improvement and proliferation of weapons and other technologies capable of denying access to or freedom of action within an operational area.[10] [Additionally], the joint command and control system will have to include techniques, procedures, and technologies that enable commanders to integrate operations across domains in innovative ways."[11]

This A2AD-focused technology study affords support to NAVAIR and NAWCAD leadership in that it is framed to connote what A2AD logically and technologically implies to U.S. Forces and force planners as well as what A2AD means for NAVAIR and specifically Naval Aviation technologies. Steps to address A2AD technologies are afoot, yet there are transitions that need to take place, like the integration of technologies into the U.S. fleet and order of battle and their coordination across services. This may be increasingly important in the future, for example, as more emphasis is placed on "unmanned systems" – those systems that have a variable level of machine automation and human interaction and may be programmed on-the-fly. The implications for the future of institutions like NAWCAD are examined in light of such advancements in the art and science of war-fighting. For the near future, the impact of advancing A2AD technologies on technical workforce requirements, skill sets and people is also desirable.

This report suggests the critical need for coordination, information exchange, critical thinking, decision making, and change management progress for DoD institutions, (which will begin to address the technological situation vis-à-vis the U.S. and China in particular). The risk facing the U.S. and the need for creating technological and military pathways for A2AD responses are examined herein.

A robust technology update including a focus on modeling and simulation is one pathway for NAWCAD to orient and position itself as a thought leader for future high-end, high-tech threats and opportunities.

Modeling and simulation advancements will provide NAWCAD leadership with new tools and data analytics. These tools will provide reflection of the broader national security context, in order to provide a unique perspective on what matters most not only in terms of technological aviation advances for the U.S., but in terms of test and evaluation or quality assurance as well.

An actual technological risk assessment would be useful in determining perceived technological risk that takes into account expert technical stakeholders' perspectives. Addressing specific tactical and technological risks are only briefly examined in this study, yet they relate directly to operational risk for the U.S. Navy and DoD, and also link to economic and political risk of specific grand strategies. Further studies might also highlight the opportunity space for technological endeavors that matter most to trump foreign A2AD technological thinking (to deter, dissuade, deny adversaries vs. defeating them) The Navy must also prepare before joint and international leadership can synchronize to a technological rhythm. This study recognizes the need for continued analysis in light of classified endeavors as well. A generic goal of the Naval enterprise is to inform national leadership and aid in the establishment of a robust and resilient technological plan to address a multitude of future circumstances under finite budgets. In this regard, NAWCAD can assist this national security imperative with aviation-related A2AD technological risk assessments, in order to position itself ahead of demands.

One of the ways to address technological readiness, military innovations and U.S. modernization plans is to review the "near-future" state of technologies that assure access under conflict. In the case of NAWCAD it is useful to review this in relation to the "near-future" state of technology of a country such as China. Reconciling a "counter intervention" strategy with a technological order-of-battle is beneficial.

Summary

A2AD scenarios rely on the interplay of stakeholders and the manipulation of technological measures as well as the strategy associated with their use and execution. Scenarios help shed light on critical decision points via examinations of the set of the "adjacent possible" – or several potential subsets of combined possibilities that are particularly stressful. This is useful for the institutions of the U.S. Navy as scenarios yield confidence to alter the impact of future operations and technological advancements in support of quality decision making.

Separating and understanding economic context, military objectives and supporting technology is required to build scenarios that inform a robust and resilient higher level grand strategy, that addresses A2AD at scale for example. Nations such as China are likely considering scenario development as well.

The nature of exploration of scenarios may yield a future game-changing set of possibilities. Deliberate exploration of models and simulations using a future orientation or subset of revolutionary capabilities is largely unexplored territory for the DoD in the greater conversation with its industry and academic partners. This would be best served through legitimate public-private collaboration. Thoughts can be solicited from private industry to assist preparations and naval readiness.

ETC's research suggests there are organized ways to consider and model the use of foreign technologies, economic offsets and scientific endeavors (for gaming, decision making, etc.). Research also suggests advancements that might inform A2AD thinking would be important to model and game to decipher risk to build confidence for the future. Insights generated have the power to greatly impact strategy formulation in order to inform decision makers of the propensity for certain technologies to accelerate or decelerate operations at scale, or, more importantly, increase or decrease operational risk to forces. In conclusion, this short look at A2AD offers some recommendations for positioning in that regard; for modeling and simulating scenarios to enhance policy adjustments to U.S. Naval Aviation roadmaps and DoD science and technology planning.

The first steps are to establish a baseline of context, particularly in military, economic and technical terms. Chapters Two and Three offer the economic context for A2AD scenario development. Chapter Two begins with a microeconomic comparison and assessment of technical capabilities and posits an effect on capacity and grand strategy. Chapter Three advances a microeconomic assessment with a macro-economic and historical analogy of the same. Chapter Three also examines the macroeconomic counter-arguments. A2AD is then assessed in subsequent chapters from both a military and a technological position after weighing those factors of economic context. Chapters Four and Five lead to military and technical scenario development and shed light on perceptions by leaders who have currently grappled with A2AD scenarios for the institution. Chapters Six and Seven examine the implications for NAWCAD and translate recommendations to meaningful opportunities for NAWCAD, such as a robust modeling and

simulation capability that will be highlighted as an effort to assist future planning.

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[1] NAVAIR (Naval Air Warfare Systems Command) is the U.S. Navy's Naval Aviation Systems command whose mission is to provide full life-cycle support of naval aviation aircraft, weapons and systems operated by Sailors and Marines. This support includes research, design, development and systems engineering; acquisition; test and evaluation; training facilities and equipment; repair and modification; and in-service engineering and logistics support. The Naval Air Warfare Center Aircraft Division of NAVAIR maintains air vehicle systems and trainers. The NAWCAD is the steward of test ranges and facilities, laboratories, and aircraft necessary to support the U.S. Navy's fleet's acquisition requirements. (Retrieved from www.navair.navy.mil)

[2] This A2AD study focuses mainly on the Pacific and Eastern hemisphere in transition, as a backdrop for A2AD. This study applies A2AD theory and research to that region of the globe. This study is offered to rapidly advance those who are not familiar with A2AD to the current example in the Pacific, to highlight a contemporary example of an A2AD application.

[3] Andrew F. Krepinevich et al., Meeting the Anti-Access and Area Denial Challenge, (CSBA, 2003).

[4] DoD, Annual Report to Congress on Military and Security developments involving the PRC, 2012. "China's long-term, comprehensive military modernization is improving the PLA's capacity to conduct high-intensity, regional military operations, including *counter-intervention* operations. For China, "*counter-intervention*" refers to a set of operationally-defined tasks designed to prevent foreign (e.g., U.S.) military forces from intervening in a conflict and preventing China from accomplishing its military objectives. China employs anti-access/area-denial (A2/AD) weapons in support of this broader *counter-intervention strategy* – a strategy not bound by a set geographic area or domain." Note: Definitions are useful as entering arguments. However, counter-arguments exist that call into question "counter-intervention" philosophy. For example, Fravel and Twomey, "Projecting Strategy: The Myth of Chinese Counter-intervention," January 26, 2015, Washington Quarterly, GW University Press, refute the idea of counter-intervention, claiming it is only used in reference to a Taiwan straits scenario. Yet, it is useful to examine 'counter-intervention' *and* A2AD thinking in terms of "what if"-worst-case situations, which provide more value than can be expressed in a simple, isolated clause or definition. Counter-intervention as a strategy represents a possibility set that is stressful to the institutions of the Navy for planning purposes. For planning purposes this is desirable. Furthermore, as exemplified through dynamic game-play of A2AD scenarios, A2AD may be applied by a nation-state in numerous ways, via a multitude of means at various scales, for a variety of desired end-states. Yet the differences between Eastern and Western philosophy on the concept are noteworthy and combine to round out a more robust look at the intricacies of A2AD.

[5] Montgomery, Evan. *Contested Primacy in the Western Pacific, China's Rise and the Future of U.S. Power Projection*, International Security, Vol. 38, No. 4 (Spring 2014), pp. 115–149, 2014 by the President and Fellows of Harvard College and the Massachusetts Institute of Technology.

[6] Cliff, Burles, Chase, Eaton and Pollpeter, Entering the Dragon's Lair: Chinese Anti-Access Strategies and their Implications for the U.S., 2007 RAND Corporation.

[7] Many will debate the 'likelihood' argument of encountering A2AD scenarios, or debate the scale issue by decoupling A2AD from full-scale theater level war. To temporarily forgo the "likelihood" discussion and consider A2AD at scale is to thoughtfully examine and understand the "what-if" of A2AD scenarios made manifest in order to stress the institutions to the max for the sake of game-play and learning. Both likelihood and severity of potential outcomes are distinct parts of a full risk examination for A2AD. However, for the purposes of this study Chapter 3 addresses the likelihood discussion, and the rest of this study assumes A2AD situations are 100% likely, in order to conduct an analysis of technical preparations, fleet readiness, execution, technical soundness of underlying principles, relevant solution sets.

[8] Jeremy Page, Wall Street Journal, "China Expands its Maritime Fortresses", February 19, 2015, p. A6.

[9] Annual Report to Congress on Chinese Military and Security Development, 2014.

[10] Dempsey, Joint Operational Access Concept, p. 7

[11] Dempsey, Joint Operational Access Concept, p. 37

Chapter 2

Operational Context: A2AD / Counter-Intervention Micro-Economic Analyses

Operational context can be derived from the confluence of many factors. Economic considerations are among the most influential elements of national power in that regard. This chapter is devoted to micro-economics and economies of scale to set context for further exploration. The goal is to include microeconomic analyses in order to game A2AD in VUCA circumstances. Economic considerations set a unique backdrop for potential friction points when viewed with the lens of A2AD planning scenarios. As the Pentagon focuses on a shift to the Pacific, the development of these micro-economic analyses is therefore focused on China and A2AD in the Pacific region.

Current Budget Breakdown

Since 1989, in every year except 2010, China's defense budget has experienced a double digit per annum increase[12]. China announced the defense budget for 2014 will show a 12.2% increase from 2013, totaling $132 billion[13]. Taking into account transparency issues and off-budget expenses the U.S. Department of Defense predicts the Chinese Defense Budget will exceed $180 billion in FY2014[14]. There are many known reasons for this ever increasing defense budget, but it is the unknowns that capture U.S. focus. Increases in China's defense budget over the past twenty years comes at a time of no evident outside threat to China, contrasting normality in relation to earlier periods in the People's Republic of China's history[15].

Every fiscal year, the U.S. Department of Defense (DOD) releases a detailed list corresponding to the defense budget appropriation of funds. For FY2015, the DOD allotted 39% of the $495.6 billion requested defense budget to operations and maintenance, 27% to military personnel spending, 19% to procurement costs, 13% to research, development, test, and evaluation, 2% towards military construction, and less than 1% towards revolving and management funds and family housing[16]. The detailed 125 page report outlines key themes in the budget and provides transparent allotment of funds. The People's Republic of China releases no such document. In fact, the last time China released a budget

breakdown was 1997 in which China claimed their defense budget was comprised of personnel expenses, maintenance of activities, and equipment ranging between 31% and 36% for each component[17]. Over fifteen years have passed, with double digit growth happening every year except one, yet nothing has been released on where this money is going. It is interesting to contrast this with Chinese leadership perspectives from the 1990's that still resonate with the current regime. It was Deng Xiaoping's dictum that postulated the following strategic foundation: "observe calmly; hide our capabilities and bide our time; be good at maintaining a low profile; and never claim leadership."[18] In 2011, these comments conveyed the interest in keeping distance with major powers while securing internal plans, and add to the mystery of how double digit growth is being utilized.

One of the greatest concerns for U.S. military strategists is China's budget appropriation towards current and future research and development of A2AD tactics. Analysis of Chinese doctrine shows the PLA has invested in information systems as a potential anti-access measure because of the U.S. military's reliance on technology[19]. The PLA may believe attacking U.S. information systems would disrupt communications to the extent of degradation or paralysis of U.S. forces, denying them access to information on enemy location. Information warfare could involve "soft-kill" tactics, involving electronic jamming and computer network attacks, or "hard-kill" tactics, involving explosives and focused kinetic energy attacks. Affecting computer systems, command and control nodes, space-based systems, reconnaissance, and communication technology would most notably exploit these tactics. Attacks against logistical systems are also discussed, showing a goal of delaying timely supplies for forces. These attacks may include blockades, attacking resource depositories, and striking air or sea supply operations. PLA writings show that an onset of attacks on air bases and ports would also be an efficient way of gaining superiority in the air or sea medium. Investments in these areas have been noted[20].

A great concern for the PLA with respect to investments is the large role aircraft carriers and destroyers play in U.S. operations. U.S. naval operations greatly outflank Chinese naval operations, however China has a developed several viable anti-ship weapons. The use of air- and sea-launched cruise missiles in conjunction with submarine-launched torpedoes and ballistic missiles, cyber attacks, and unmanned aerial and undersea vehicles could be used to overpower a destroyer or carrier's

defenses[21]. This layered strategy can be readily assembled from many types of procurements, as highlighted in this document:

> "…advocated the use of large numbers (54) of Harpy anti-radiation cruise missiles, which would crash into the radars of the destroyers. These attacks would be backed up by anti-radiation missiles launched from SU-30 aircraft. After the radars were disabled, additional SU-30s and Kilo-class submarines and Sovremenny destroyers could sink [and finish] the ships."[22]

Context is established from these investments. If the aforementioned tactics were employed, the net result could considerably disrupt U.S. military operations as a whole by forcing troops to operate from unfavorable locations. Thousands of miles between the U.S. and the Western Pacific causes concern regarding the ability of the U.S. military's access to regions where China is intent on denying access. Initial attacks consisting of "cyber or physical operations against command-and-control nodes together with American space-based ISR assets" would be necessary to provide a foundation for a counter-intervention operation[23].

This foundation could then be followed with a combination of maritime-based air, missile, or special operation attacks in the region. The PLA has acquired and enhanced their A2AD ability by integrating capabilities of:

> "Offshore offensive and defensive military operations along the littoral of the Western Pacific (extending out approximately 1,500 nautical miles to the so-called first island chain, which includes the Kuril Islands, the main Japanese islands, the Ryukyu Islands, Taiwan, the Philippines, and Indonesia, along with much of the Yellow Sea, the East China Sea, and the South China Sea), strategic deterrence and counterattacks, and long range precision strikes and sustained operations. This also includes the ability to defend Chinese claims over its territorial waters and within the 200-nautical-mile exclusive economic zone (EEZ)."[24]

The most significant procurement and program to date, in terms of applicability to anti-surface naval warfare and A2AD implications, is the DF-21D. The DF-21D is an anti-ship ballistic missile with a 1,500-kilometer reported range that could prove grave prominence over an aircraft carrier. There are also reports that proclaim China is developing a variant missile with a longer range than the DF-21D that could conceivably be deployed before 2030 (51).

Although not all of the budget appropriations are abundantly clear, personnel costs are unavoidably escalating. Many believe that this increase is attributable to Beijing's effort to compensate the PLA for the hefty forfeitures suffered in the 1990's when leadership forced the military to dissociate from commercial assets. What is clear is that a large portion of the increase is due to rising personnel wages, along with annuities for demobilized personnel, resulting from the diminution of PLA workforce implemented in 1997[25]. This increased spending due to wages does not necessarily translate into amplified capabilities for the PLA.

> "Between 1994 and 2006, of three key budgetary categories---(1) personnel; (2) operations, training and maintenance; and (3) equipment---personnel expenditures grew the most---581 percent. Moreover, large pay raises were authorized in 2006, 2008, and 2011; the 2011 raise provided a 40 percent hike in the salaries and benefits of noncommissioned officers."[26]

Additional analysis shows that the rising Chinese defense budget also comes from outsourcing to acquire weapons. China's domestic defense industries have been historically weak, stemming from leadership under Mao Zedong where factories were placed in hard-to-reach inland areas in order to achieve self-sufficiency[27]. Reforms were employed in the late 1970's, but they failed to reorganize defense production because of military budget constraints.

> "By the late 1990's, 40 percent of China's defense companies were estimated to be losing money, and were only staying afloat thanks to massive subsidization. Many plants in the most remote 'Third Front' region of the country were only being utilized at a rate of 10 to 30 percent."[28]

This situation has caused China to rely heavily upon foreign acquisition in order to heighten technological advancement.

> "Between 1989 and 2010, China purchased more than $28 billion in arms from Russia (previously the Soviet Union), and some observers point to evidence that Russia has helped supply China with crucial designs and capabilities for key technologies. Despite these transactions, however, Beijing often finds Moscow a less-than-willing trading partner when it comes to highly sensitive, valuable weapons and systems components."[29]

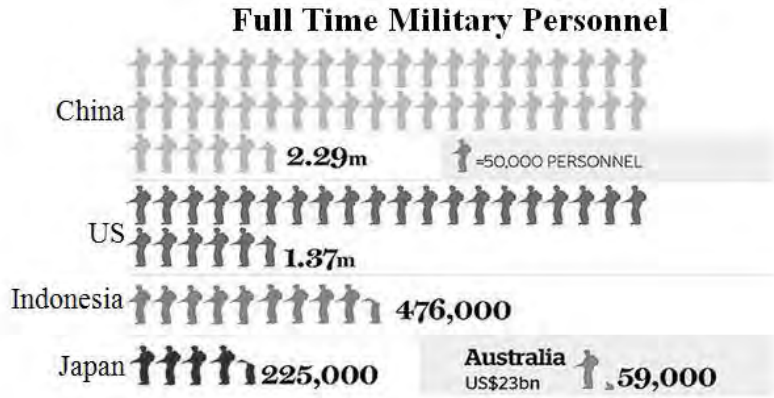

Figure 2: Adapted from the Sydney Morning Herald

Of particular concern to U.S. counter A2AD strategy is that Russia is beginning to deal more sensitive and effective arms to China. Russia is in the process of selling six Lada-class attack submarines and thirty-five SU-35 fighter jets to China. China is also trying to acquire the S-400 missile defense[30]. China is also trying to acquire the S-400 missile defense system, with a range of nearly 250 miles (which can cover the entire airspace over Taiwan).[31] The United States continues to apply pressure on European nations to hold embargos on weapons exports to China[32]. This effort has forced Chinese military planners to focus on defense sector modernization through China's civilian economy and applied research-and-development. Analysts say that specific capabilities with practical likelihood of progress include missiles, shipbuilding, defense electronics, aviation, and certain space technologies.

> "China's 'Twelfth-Year' Plan identified the shipbuilding and electronic information industries as key sectors meriting further restructuring. Beijing has also placed a priority on developing advanced indigenous radar, counter-space capabilities, secure C4ISR, smart materials, and low-observables technologies by 2020."[33]

This allotment supports the notion that both naval and aviation technologies that are the basis for the Chinese A2AD strategy are a growing focus of investment for the PLA. In fact, consideration must also be given to the notion that some sole source dependencies exist on critical materials and This allotment supports the notion that both naval and aviation technologies that are the basis for the Chinese A2AD strategy are a growing focus of investment for the PLA. In fact, consideration must also be given to the notion that some sole source dependencies exist on critical materials and supply chains that stem from China. Does the U.S. also need to ensure, in light of A2AD counter-measures, that in-house sources will make the U.S. defense establishment less vulnerable?

Current Trends

Most experts agree that China will continue to experience double-digit increases from year to year in defense spending over the current decade[34]. Experts also agree that the PLA will continue to implement progressive military platforms and advanced technologies that cause disquiet for the United States and its allies[35]. Trends expanding over fifteen to twenty years are less precise due to the unpredictability of the forthcoming pecuniary growth levels along with any government changes that link to social tensions or other nationalistic necessities. Many analysts predict that Chinese GDP will continue to grow, however, at a declining rate[36]. Sustaining double-digit per annum growth of defense spending will prove arduous during times of no conflict. Projections could necessarily overestimate future defense expenditure growth if Beijing directs resources towards domestic investments like social welfare and internal security. Instead, if domestic stability is experienced and foreign threats emerge then the PRC's military spending could increase at a higher rate than both GDP and government expenditures.

> "[I]f Beijing can implement key financial reforms, such as improvements in its tax regime, it could significantly increase its government revenue and thus increase its level of government expenditures from the current (official) rate of about 22 percent of GDP to perhaps as high as 35 or even 40 percent of GDP, which is more in the realm of what is spent by most countries that belong to the Organization for Economic Cooperation and Development (OECD)."[37]

China continues to show evidence that they are one of the fastest growing economies in the world. Many anticipated that growth would decline because of China's desire to obstruct inflation; however, growth has continued to be roughly ten percent[38]. On the other hand, the RAND Corporation believes that growth will taper off towards three percent by 2025 due to a declining work force, inadequate savings by an older population, declining trade because of a saturated market, feeble financial institutions, and other domestic issues[39]. Global Security also predicts that poor allocation of funds might also halter military modernization. The RAND Corporation speculates four distinct areas that will define efficacious modernization of the PLA: prolonged economic development, capacity to accumulate fiscal revenue, competing domestic interests (wages, health care, education, etc.), and the capability to manufacture innovative weapons similar to that of the United States[40].

Leadership dynamics and civil-military relations also shape Chinese economic trajectories. The military remains mainly under civilian control but a concrete disconnect between local military and para-military challenges investments as well as heightening crisis probability[41]. China incurs a large long-term risk of demographical challenges that include a shrinking labor force, a large gender imbalance, and an aging population that will need to be supported[42]. Although these risks will unquestionably pose a longer term economic risk, the 2030 outlook will likely be unscathed by these factors because of the ability of the leaders of the Chinese Communist Party to alleviate some of the corresponding effects[43].

The current decade has revealed an extraordinary rise in Chinese investment opportunities in the United States. U.S. firms currently account for $50 billion of every $1 trillion of revenue in China due to foreign ventures such as mergers, procurements and Greenfield Investment in the latest facilities[44]. China has yet to see foreign direct

investment start to take off; however, experts agree that the time has arrived. Fluctuating competition and viability in China is creating incentives for Chinese corporations to capitalize in the United States. In the past, China has focused its foreign investment on securing raw materials, but now direct capital investment in America is mounting in both worth and quantity of deals[45]. In 35 of the 50 U.S. states, Chinese conglomerates have generated jobs and set forth operations in both industrial and service businesses[46]. Daniel H. Rosen and Thilo Hanemann of the Kissinger Institute on China and the United States see the prosperity that Chinese investment can provide, particularly in the number of jobs:

> "Official data tend to obscure the exciting reality that the United States is open to Chinese investment and that that investment is, in fact, arriving in increasingly larger amounts—more than $5 billion in 2010 alone. The actual number of jobs that Chinese investors have created likely exceeds 10,000—many times the official estimate."[47]

The Wilson Center also realizes the impending Chinese economic involvement throughout the world:

> "If China follows the pattern of other emerging nations, more than $1 *trillion* in direct Chinese investment will flow worldwide by 2020, a significant share of which will be destined for advanced markets such as the United States."[48]

Although Chinese investment in America has its strengths, the many potential downfalls that accompany such investment cause hesitation and ill will amid the two countries. Congressional interference has diminished the probability of tranquil investment and has warded off many legitimate proposals. This scenario has taken place previously when Japan first began investing in America:

> "Japan's first investments in the United States during the 1980s were almost as controversial as China's, but in the following years, U.S. affiliates of Japanese companies invested hundreds of billions of dollars in the United States, and today employ nearly 700,000 Americans."[49]

Chinese investment and the prosperity of the nation to protect itself have a direct correlation with military expenditures. In every scenario, China's defense spending will most likely continue to increase over the next fifteen to twenty years. Although defense spending does not compare to that of the United States today, China is on its way to purchasing power parity, which will establish regional power and credibility over the next decade.

Purchasing Power Parity

The relative version of purchasing power parity (PPP) is an economic theory that adjusts a country's currency by accounting for differences in exchange rate. A simple version of PPP is shown by the following equation:

$$S = \frac{P_1}{P_2}$$

Where "S" signifies the exchange rate of currency 1 to currency 2, P_1 signifies the cost of the good in currency 1, and P_2 signifies the cost of the same good in currency 2[50].

The current exchange rate from Chinese Yuan to U.S. Dollar is 1 Chinese Yuan equals 0.16 U.S. Dollar[51]. To get a more exact PPP the equation becomes more involved, incorporating more factors, such as following that adjusts for only inflation:

$$\frac{S_1}{S_0} = \frac{1 + I_y}{1 + I_x}$$

Where S_0 is the exchange rate at the beginning of the time period, measured as the "y" country known price of one unit of currency "x"; S_1 is the exchange rate posted at the end of the time period of calculation; I_y is the expected annual inflation rate for country "y", the foreign country; and I_x is the expected annual inflation rate for country "x", the domestic country[52].

China's continued economic development has driven their level of defense spending to increase steadily over the past twenty years. Although the defense spending as a percentage of GDP has remained relatively constant, the continual rise of GDP causes understated defense spending[53]. In 2011 China's official recorded defense budget was $91.5 billion, although the Stockholm International Peace Research Institute (SIPRI) estimates a figure $29.6 billion higher at $121.1 billion[54]. The U.S. Department of Defense also estimated that China's defense budget surpassed $120 billion in 2011[55]. These differences are shown in the following table:

2011 Chinese Military Expenditure (in billions of nominal U.S. dollars)

OFFICIAL PRC	SIPRI ESTIMATE	U.S. DOD ESTIMATE
91.5	129.3*	120–180†

* In constant 2010 U.S. dollars.

† In 2011 dollars and exchange rates.

TABLE 2.2

2010 Chinese Military Expenditure (in billions of U.S. dollars)

NOMINAL OR PURCHASING POWER PARITY (PPP)	OFFICIAL PRC	IISS ESTIMATE	GILBOY AND HEGINBOTHAM ESTIMATE	SIPRI ESTIMATE	U.S. DOD ESTIMATE
Nominal	78	111.1	113.3	121.1*	>160
PPP	94.9˘	178†	138.2‡	—	—

* In constant 2010 U.S. dollars.

˘ Estimate for the 2010 official PLA budget from Eric Heginbotham and George J. Gilboy, *Chinese and Indian Strategic Behavior* (New York: Cambridge University Press, 2012), 307, with an implied PPP conversion factor of 1.21.

† Implied PPP conversion factor of 1.61, as given by International Institute for Strategic Studies, *The Military Balance 2012* (London: International Institute for Strategic Studies, 2012).

‡ Implied PPP conversion factor of 1.22; Heginbotham and Gilboy, *Chinese and Indian Strategic Behavior*, 307.

Table 1: China's Military and the U.S.-Japan Alliance in 2030: A Strategic Comparative assessment

Strictly numerically-based outlines do not tell the full story since differences in manufacturing costs, personnel wages, and other internal expenditures dictate that one dollar of U.S. defense spending can purchase less than one dollar equivalent of China's defense spending[56].

Approximating China's defense spending at $120 billion, this is over six times less than the nominal defense spending of the United States in 2011[57]. This difference is further explained by purchasing power parity (PPP). The International Institute for Strategic Studies concluded that in 2010 China had a PPP multiplier of 1.22 for the corresponding defense budget[58]. PPP shows a perplexing difference between nominal and real figures.

The CIA World Fact Book, Stockholm International Peace Research Institute (SIPRI), and the International Institute for Strategic Studies (IISS) all have their own way of calculating PPP[59]. They incorporate a multitude of factors that highlight key differences between Chinese and U.S. military spending. There is no distinct, uniform way of calculating military expenditures worldwide. Calculating purchasing power parity conversion factors takes into account differences in the following elements and more:

- Salary
- Healthcare

- Retirement Expenditure
- Research and Development
- Hardware Costs
- Maintenance
- Deployment
- Taxation

PPP based expenditures indicates a more current financial burden that a country's military places on their economy, as well as possible government priorities. Exchange rates are readily available and are determined by analyzing the supply and demand of currencies used in international market transactions. Since market exchange rates do not successfully reflect differences in price levels between countries, PPP exchange rates are used to unify a relative price level and provide a measurable purchasing power for each country.

Accurately measuring the purchasing power of a nation is difficult and PPP rates are often subject to unreliability due to lack of transparency and comprehensiveness. Many countries only release limited information corresponding to military spending, making it challenging to quantify relative purchasing power from just a top-line defense budget figure. Other countries publish military expenditure figures but methodically omit significant items to correspond with their overall state budget, or, to remain unseen by the public.

In estimating China's defense budget, SIRPI takes into account the amount of credible sources that show military expenditures, outside of China's official published budget. Many of these sources come from central government ministries and internal PLA sources. Accounting for the items listed previously, SIPRI estimates that the actual Chinese defense budget is nearly 1.5 times the official budget[60]. The International Institute for Strategic Studies calculates a conversion factor of 1.61 and the RAND Corporation believes the PPP conversion factor is around 1.22. The U.S. Department of Defense (DOD) indicates that China's purchasing power is even higher than that based on demonstrated and fielded military capability. The DOD predicts a conversion factor of 1.68+ and that it will continue to rise[61].

Using the purchasing power parity conversion factor of 1.68, denoted by the U.S. DOD, continual ten percent per annum growth of the Chinese defense budget and official published budgets by the Chinese government, a future forecast model shows an alarming trend.

When compared with the current U.S. defense budget of $640 billion, the graph above shows that China will have equal purchasing power

around 2025 and will double current U.S. defense budget purchasing power in 2033. Adjusting the data in accordance to the 2014 U.S. DOD estimate of China's defense budget being near $180 billion, due to off budget purchases and budget omissions, the data shows an even more disturbing prospect.
The graph below shows that the Chinese defense budget will equal purchasing power to current U.S. defense budget around 2021 and double the current U.S. defense budget purchasing power in 2028. Although these calculations are conjectures that can easily be affected by basic assumptions and growth prediction, they bring to light a growing apprehension concerning U.S.-Chinese military stability in Asia.

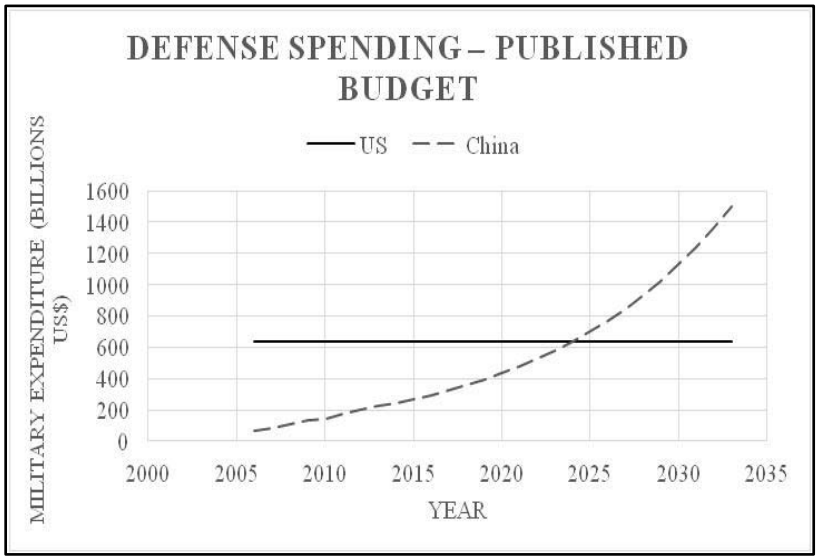

Figure 3: Projected defense budget using current US budget and current Chinese published budget multiplied by a PPP factor of 1.68. Chinese budget trend line increases due to a 10% per annum growth, US budget held flat.

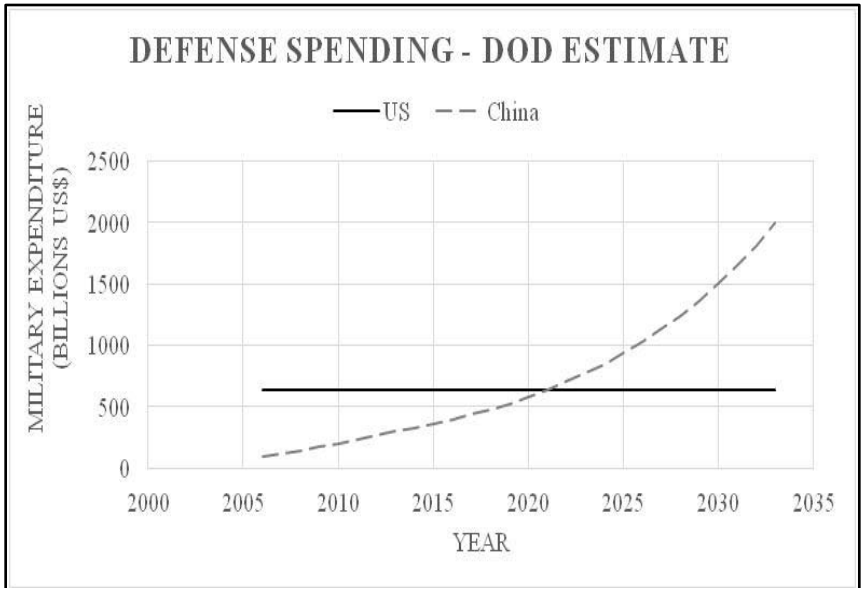

Figure 4: Projected defense budget using current US budget and current Chinese DOD estimated budget multiplied by a PPP factor of 1.68. Chinese budget trend line increases due to a 10% per annum growth, US budget held flat.

U.S. Impact from Chinese Defense Budget

China's approach is suspected to involve either a "Cautious Rise," emphasizing engagement, or "Assertive Strength," emphasizing hedging[62]. Both approaches will involve an increase in defense spending because of a needed increase in military capabilities. On the other hand, any civil strife or major economic slowdown would force China to focus on internal stabilization, shifting attention away from foreign policy. A bellicose ultranationalist approach by China is unlikely because of the required economic appropriation and the high destabilizing factor[63].

These trajectories are shaped by a variety of factors regarding China's social and developmental state. As economic capacity is reached, economic growth could slow and the economy could shift towards greater consumption. This could be tumultuous problems if leadership does not implement adequate reforms[64]. Continued low capital stocks

could, however, keep growth and investment at a high and prosperous rate[65]. More likely, China's gross domestic product (GDP) will experience a slowing of growth due to reaching economic capacity, causing defense spending to slow. Regardless of the corresponding GDP, PLA budgets will continue to grow in absolute terms[66].

An increase in the Chinese defense budget will necessarily increase capabilities relevant to a Chinese A2AD strategy. The U.S. has already begun increasing their number of forces in key areas in the West, along with "examining several possible new operational military concepts"[67]. Pentagon officials unveiled the Joint Operational Access Concept (JOAC) in 2012 to create a new emphasis on counter-A2AD in the Asia-Pacific Region[68]. China's continual growth and efforts made toward implementation of a robust A2AD strategy will most likely increase importance of the JOAC, possibly through a local sea control[69].

A2AD Micro-Economic Context

Macro-economic influence affects micro-economic policies. Chinese public opinion may support cooperation with both U.S. and their regional competitor – Japan; however, China considers the coalition between U.S. and Japan as a potential threat. The key external factors include Japanese foreign and security policy towards China, U.S. Asian-Pacific policy, and maritime calamities that might accelerate trends in the global commons[70]. The ever increasing military power China possesses is triggering concern for the United States and its alliance with Japan. In reflection on this topic, the Carnegie Endowment for International Peace published a 2013 report to address the factors surround the U.S.-Japan alliance and its relationship to China. Their "Strategic Net Assessment" evaluated relations between the three countries, including decade's forthcoming, and conveyed political observations with acknowledged diplomatic and military analyses. The foremost inquiry corresponds to the existing and possible upcoming effect of China's military capabilities and foreign policies on Tokyo and how the United States and Japan would respond in kind.

The Carnegie Strategic Net Assessment also highlighted a few significant findings. Most importantly, the Carnegie Endowment for International Peace predicts that the U.S. – Japan alliance will not experience a full-scale military conflict with China over the next fifteen to twenty years[71]. The U.S. – Japan alliance will instead potentially face a two-fold challenge that corresponds to Beijing's adverse political influence and the growing presence of the PLA near Japan and disputed

territories. This growing presence will cause significant shifts in the Chinese military and para-military capabilities. Absolute Chinese military acquisitions (gains), with a focus of missiles, naval, air, and C4ISR, is very likely[72]. Relative Chinese micro-economic gains over a variety of domains consisting of naval and air are also feasible[73]. These gains would prospectively taper the U.S. prevalence leaving Japan with a potential defense void that they will most likely not be able to fill. Countering the growing economic threat posed by China in efforts to preserve primacy for the U.S. and Japan might prove to be unfeasible. There are no easy alternatives for the United States to find balance and collective security in response to China's military capabilities and regional significance. Although many uncertainties could influence trends, any worst-case outcomes involving the trio of nations are unlikely. China's threat to the U.S. – Japan alliance would take a considerable hit if the Chinese economy abates[74]. This would cause Beijing's concentration to shift toward sustaining internal solidity.

The Carnegie Strategic Net Assessment dictates that no single response can deliver military or political balance that delivers only minimal cost to each country at hand[75]. Every probable response necessarily involves tradeoffs that challenge regional security and calls for radical new thinking by one or more country involved. There are three broad-spectrum political-military responses that serve to advance an overall allied interest in the long run. Robust forward presence, conditional offense/defense, or defensive balancing tactics are the most viable options for progression[76]. These responses can be inhibited by a multitude of factors that mainly correspond with political endeavors versus economic endeavors. If the United States is unwilling to alter doctrinal assumptions while working with the Western Pacific then diplomatic negotiations are highly unlikely - uncertainty among stakeholders could result in complications over vital security interests[77].

The Carnegie Endowment for International Peace ends their comparative assessment with a call for [economic] modification bringing to light a growing concern that a stable security environment between China, Japan, and the United States is in jeopardy over the long term. The U.S. may face an uphill battle that is comprised of situations involving budget problems and high-risk management. There are three main aims to advance U.S. policies in the best way possible. First, assuaging any reservations of U.S. entrapment or abandonment in Tokyo; next, improving Sino-Japanese relationships by aiding in peaceful disputes and emboldening cooperation; lastly, maximizing the

probability that Tokyo adopts U.S. polices that enhance the ability of U.S. interests. The likelihood of successfully meeting these goals depends on many factors. Always concerning foreign policy is the state of Washington's political and diplomatic relations with China, most importantly Tokyo and Beijing. Economic and technological based funding will also be a relevant issue in order to maintain efficient defense spending[78].

The RAND Corporation's report includes a number of actions the United States can take to counter Chinese anti access measures. The United States needs to counter the critical threat of Chinese missile and air attacks on U.S. air bases by investing in passive defenses at key air bases[79]. This could be done by investing in strengthening runways, hardening shelters, and constructing underground fuel tanks[80]. Adding to passive defenses by creating active defenses limits the effectiveness of Chinese ballistic missiles. Deploying air and missile protection methods such as the Patriot Advanced Capability-3 (PAC-3) system can play a valuable role in responding to attacks on essential facilities[81]. Defenses could also be strengthened against covert operatives by installing anti-sniper systems and formidable perimeter security[82].

Another method of counter, proposed by the RAND Corporation, involves diversifying options for housing aircraft. This action would cause China to distribute resources over a large array of targets, rendering them less effective (micro-economic pressures). RAND goes on to highlight the need to reduce vulnerabilities, starting with naval forces at port. Pre-conflict, periodic scanning for mines and submarines is necessary and should be rapidly enhanced during conflict. Vulnerabilities concerning C4ISR systems should be reduced and out of date technologies might be available for back up in the case of China disrupting the ability to communicate[83]. Steps could be taken to deter and mitigate as well as resist and counter the use of high-altitude nuclear detonation by China. Finally, the RAND Corporation reaffirms the vital role allies play in anti-access confrontations. The U.S. needs to strengthen relationships with regional allies to maximize territorial primacy[84].

Many improvements to U.S. capabilities need to be made to enhance the ability to counter Chinese anti-access tactics. The ability to intercept and destroy ballistic missiles could alleviate a major threat towards defense systems. As China further develops, existing U.S. PAC-3 and sea-based Aegis Ballistic Missile Defense systems could become out of date[85].

An extremely challenging project that the U.S. is facing is the ability to detect, identify, and attack mobile time-sensitive targets[86]. This ability could prove valuable to countering many missile anti-access threats. Improvements also need to be made in defending both advanced ship born cruise missiles and land-based cruise missiles. China's submarines and mines present a major problem with the United States' ability to have successful sea deployment[87]. Robust satellite surveillance and anti-satellite capabilities reduce effectiveness of China's anti-access attacks. Counters to China's SAM systems and long-range surface-to-air and AAMs could provide the U.S. with stealth and surveillance abilities along with defensive abilities. All of these aforesaid improvements and potentials increase in efficiency if the U.S. is preemptive with early strategic and tactical warning capabilities[88].

Conclusion

The principal factor motivating increases in China's defense budget likely stem from the PLA's need for modernization and personnel improvement in order to safeguard China's homeland and proclaim primacy over disputed regional and maritime claims[89]. The PLA's weapon systems aim to deter any third-party into settling disputes on terms favorable to Beijing. These weapon systems also serve as anti-access armaments that discourage third-party intervention. A rising, but ambiguous percentage of China's defense budget is going towards deploying destroyers and frigates for naval diplomacy missions[90]. This could be seen as measures focused towards antipiracy and providing public goods. On the other hand, this raises concern for the United States and its allies because of the future implications posed by a growing Chinese fleet.

Chinese defense spending is increasing, with constant double digit per annum growth since 1989, excluding 2010. The nominal, published Chinese defense budget for 2014 is $132 billion. Transparency issues, off-budget purchases, and budget omissions cause the U.S. DOD to calculate that the Chinese defense budget is much closer to and perhaps exceeding $180 billion. The purchasing power parity conversion factors for Chinese military expenditures range between 1.22 and 1.68+. Using the DOD estimated budget and conversion factor multiple, the Chinese defense budget assimilates to $300 billion, a 227% increase (since 1989). Using current trends and these conversion factors, the Chinese defense budget will equal the current U.S. defense budget (in terms of purchasing power) between 2021 and 2025. *The Chinese defense budget could be*

double that of the current U.S. defense budget in terms of purchasing power between 2028 and 2033.

This data raises a multitude of perplexing U.S. implications that need to be addressed. If China's defense budget continues on its current progression, the current level of A2AD advantage that China maintains will skyrocket. Changes will have to be made across the board for harmony to be maintained. The United States will most likely see a decreased ability to control the six major domains of possible military competition. On the other hand, China will increase its capacity to challenge others in several domains (undersea and cyberspace for example). The resulting appropriation depends on many unknown factors. However, the subsequent dynamic might prove unstable unless the U.S. alters not only economic, but political and security strategies towards China.

Monitoring economic indicators, social media, and regional propagation could add additional insight into Chinese budgetary considerations. Evaluating their competing domestic interests would further quantify budget appropriations and allotment of funds. Conducting this study of purchasing power parity underscores a correlation between a growing gross domestic product and a budding middle class. All of these studies help correlate and predict a future defense budget forecast in synchronization with contentious national interests (territorial disputes, resource claims, economic positioning, etc.).

If the micro-economic indicators of power yield some form of future parity, this significantly affects the macro-economic climate, A2AD perspectives and strategic positioning of Asia-Pacific nations as well. In summary, if China's defense budget is causing legitimate concern, or at least increasing skepticism, can the U.S. afford to maintain its current course?

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Chapter 3

Historic and Macro-economic Context for the Contemporary Chinese A2AD Challenge

The processes that take place in a system are affected by its structure…The preferences of the states predispose them toward certain strategies; the structure of the system provides opportunities and constraints.[91]

In the history of international relations, leading strategic powers have more often than not also been leading economic powers and have frequently fought to uphold the preferential arrangements that sustained their position. Warfare has predictably accompanied the rise of secondary powers to the apex of the international system. The historical record suggests that the United States, as it experiences a broad relativization of its power in the coming generation, should expect a greater likelihood of conflict as other aspiring states grow wealthier and more powerful, and as those states further develop the means to impose increasingly high costs on U.S. forward presence and power projection, the two most visible manifestations of U.S. power. This is particularly true in Asia, where since the Second World War the United States has resolutely asserted itself as the preeminent power from motives as durably true today as they were in 1945. In the broadest terms, the U.S. has acted from the desire to establish the terms on which Asian regional stability is decided and to uphold a commercially unfettered, international market system consistent with its way of life. This plan was abetted by the end of European colonialism throughout the region and the U.S. determination to prevent another potentially hostile hegemon from emerging on the eastern Asian landmass. The U.S. "grand strategy of primacy," as one might term it, has depended upon a consistent forward military presence.

No power in the world today presents as strong a challenge to the U.S. strategic profile in Asia as does China. Over the next quarter-century, it is possible that China's gross domestic product (GDP) and defense budget could exceed those of the United States.[92] If it chose, China could therefore become a more capable opponent than either the Soviet Union or Nazi Germany at their peak. To date, and beyond imputations, the Chinese government overtly seeks neither territorial expansion nor

ideological sway over its Asian neighbors or trading partners abroad. While analysts often impute a broad range of intentions to the growth of Chinese defense spending, the Chinese government outwardly displays no purposive interest in achieving the same level of expenditures as the United States. It also has made only tentative steps toward achieving a capacity for global power projection or taking on strategic commitments beyond its immediate periphery. However, as the Chinese economy continues to expand, there is every reason to suppose that the country's leaders will feel themselves subject to the same interest-based imperatives as U.S. statesmen, and craft policy in a manner consistent with them.

In doing so, Chinese leaders will confront telling constraints. The demographic profile of the country, like that of other countries in northeast Asia, is generally shifting. There is little question that China's workforce will shrink in the current decade, along with its population more generally in the next. This prospect is common to the developed Asian economies: Japan, South Korea, and Taiwan will also experience population declines, even as the median and mean age distributions within the populations shift. But countries throughout the region have high – and continually increasing longevity – which suggests that the proportion of older persons and retirees will rise relative to the overall populations. These societies, like many around the world, will be forced to confront the implications of resource transfers from young to old and shifts from other forms of government spending to pensions and health care. The Chinese population cohort eligible for military service, for example, will decline by a third over the next three decades, presenting the leadership of the country with fundamental problems.

Growth and modernization through trade has been a central objective of Chinese state policy since Deng Xiaoping reformed Chinese economic relations with the rest of the world in 1978. Deng shifted the impetus of Beijing's foreign policy from support for national liberation movements and ideological struggle to the promotion of growth-enhancing trade with almost any other willing state, but especially with the United States, from which the Chinese leadership hoped to derive key best practices for industrial organization and finance. Peaceful trade is bound intimately to security: official foreign and strategic policy statements have long emphasized the importance of regional peace and stability as fundamental for continuing growth. And although China has practiced targeted trade retaliation in economic disputes, it has not imposed sanctions designed to achieve advantageously political purposes. While it seems clear that China may be increasingly willing to tolerate some

economic costs in achieving broader strategic ends, it has walked away from several recent instances in which political conflicts appeared likely to affect Chinese trade or investment interests.

The result has been an explosion of trade with the developed world, particularly the United States.[93] In 2012, the United States imported $425.5 billion of goods from China, up from $321 billion in 2007, and only $125 billion in 2002. The United States also exported $110 billion worth of goods to China in 2012, up from $63 billion in 2007 and $22 billion in 2002.[94]Today the U.S. trade deficit with China is approximately $315 billion, up from $258.5 billion in 2007 and $103 billion in 2002. Most revealingly, perhaps, is the fact that China's trade as a percentage of GNP has soared from 13 percent in 1980 to between 35 and 40 percent by the late 1990s.[95] Few could have imagined in 1978 how rapidly and to how great an extent Chinese trade with the outside world, especially the U.S., would explode in a mere quarter-century.

Chinese integration into world commercial patterns has accompanied other, equally important forms of interdependence. At the end of May 2013, foreign investors held $5,678 trillion in U.S. debt, which amounts to "the largest share of privately held public debt attributed to foreign holdings since these estimates have been compiled," according to the Congressional Research Service.[96] Of that, China holds 23 percent, the largest of any foreign holder (Japan is the second-largest, with 19.5 percent.) Educational exchange between the United States and China, another crucial measure of interdependence, is also increasing rapidly. China is only the fifth most popular destination for U.S. students studying abroad, but the number of U.S. students studying there has more than doubled between 2004 and 2011, the last year for which data is available. Meanwhile, China is the largest source of foreign students studying in the United States with over 194,000 in 2013. That amounts to a nearly 600 percent increase since 1995 and to over 25 percent of the total number of foreign students, nearly twice the number of the second-ranking country, India.[97]

The idea that promoting interdependence and economic integration among nations is a wise strategy to advance peace, stability, and prosperity has been a charm of U.S. policy since the end of the Cold War.[98] Senior policymakers in China and the U.S. both purport to believe staunchly that interdependence will reduce tensions between the two powers. Acknowledging the unprecedented scale of economic interdependence, China's President Xi Jingping called for "a new model of major country relationships," while former Secretary of State Hillary Clinton argued that "[i]nterdependence means that one of us cannot

succeed unless the other does as well. We need to write a future that looks entirely different from the past."[99] Chinese Premier Li Keqiang speculated "I don't believe conflicts between big powers are inevitable…Shared interests often override their disputes."[100]The optimism of policymakers notwithstanding, some academic observers have argued that the consequences of interdependence across the globe are indeterminate at best and bring with them strategic challenges, both predictable and unpredictable, including greater volatility in the global economy, destabilizing vulnerabilities in the U.S.-China bilateral relationship, tensions in Asia arising from the reliance of small economies upon China, and an existential crisis in the European Union.

Undeniable, however, is that trade has provided valuable material benefits, or "gains from trade," for the citizens of both countries, as it has for most people around the world in the last two centuries. In the liberal view of trade, which dates back at least to Immanuel Kant, countries strongly dependent on trade for their economic prosperity should avoid war, since peaceful trading is thought to pay more and cost less than (even successful) wars, and gives them many other benefits of integration without the costs and risks of conquest. The enormous increase of the costs and risks of war as a result of modern technology would seem to make the argument for peace through economic interdependence even stronger. So-called Realists turn the argument on its head. They argue that increases in economic integration have created uniquely dangerous preconditions for major crises, such as the Euro-crisis and the 2008 international financial crisis, which seemed beyond the capacity of individual governments to overcome. As far back as Rousseau, critics have pointed out that interdependence not only fails to promote peace, it heightens the likelihood of war, because states strive for security and autonomy above all else. A dependence on prosperity through trade leads not to confidence but anxiety, as nations that "depend on others for critical economic supplies will fear cutoff or blackmail in time of crisis or war," as John Mearsheimer argues.[101] In particular, excessive reliance on certain key imports, such as energy or raw materials, has the potential in a conflict to endanger a country's entire economic system, and nations are least predictable when their sources of energy especially are most precarious, as seemed especially true of Imperial Japan in the interwar era.[102] Therefore, states reliant on others for vital commodities and goods have a high incentive to go to war to assure continued access. As Kenneth Waltz puts it, only certain selfish actors within a domestic polity stand to profit from trade and have reason to embrace the dependence that accompanies economic specialization.

The anarchic structure of international politics makes states worry about their vulnerability, and therefore drives them "to control what they depend on or to lessen the extent of their dependency." Economic interdependence, therefore, "will probably lead to greater security competition."[103]

Yet another trope in international relations argues that economic exchange is irrelevant to the likelihood that states will go to war. Strategic theorists as distant as Thucydides have maintained that the case for conflict on economic grounds is debatable for the simple reason that the structural-military competition between states completely dominates – or mostly dominates, at least – their political behavior. In this view, the uneven distribution of power between rising and declining states in the international system – measured variously – is the key factor in shaping their behavior. Economics may influence international relations at the margin, especially in terms of how statesmen understand relative power and its vulnerabilities, but the fundamental character of peace and conflict is not determined by such concerns. As Robert Gilpin puts it, "[n]o generalizations on the relationship of economic interdependence and political behavior appear possible. At times economic intercourse can moderate and at others aggravate these relations…In general, the character of international relations and the question of peace or war are determined primarily by the larger configurations of power and strategic interest among both great and small powers in the system."[104] Economic interdependence – or the lack of it – factor only marginally into a country's strategic outlook.

So understood, *more important than straightforward economic metrics is the competence and efficiency with which countries translate economic power into strategic potential.* Put differently, the fact of economic interdependence is less important than the complex and uncertain ways in which policymakers interpret that interdependence for their interests and prospects. As Condoleezza Rice put it, "China is a very important – I used to say emerging power, but I'll say emerged power that can no longer be ignored."[105] China has an impressive and sophisticated industrial base, a strong and centralized state, nuclear-weapons capability, a continental territorial base, a permanent seat in the Security Council of the United Nations, and an enormous and increasingly interconnected domestic market. Seen this way, one cannot overlook that implication that the United States and China, while highly and beneficially interdependent, are also strategic competitors across the Asian Pacific rim and compete for regional influence in terms not solely economic. Much in the future will depend on whether the United States

can remain the hub of the regional security order, on whose terms maritime territorial disputes in the South China Sea and East China Sea will be resolved, and whether the United States can continue to project power decisively into the region. China and the United States are also at odds on several more specific issues that could quickly escalate into a crisis, such as Taiwan and the future of the Korean Peninsula. On no single question is it likely that either China or the United States will abandon their respective positions and accede to the will of the other, especially for solely economic reasons. Even if economic interdependence increases beyond its already high degree, it does not offer much prospect of relieving the rivalry between the U.S. and China. Indeed, an enormous danger is that Washington and Beijing could well miscalculate by assuming that the other side is more heavily influenced by economic considerations than it actually is. Economic interdependence and relative strategic power interact to shape the posture of China and the United States toward one another.

In dealing with China, therefore, the United States confronts a thorny problem. Continued engagement clearly enhances the quality-of-life of millions of Americans and cushions the impact of debt-fueled government financing. But continued engagement also helps China grow in relative economic terms. If translated into military capability and strategic importance, that economic growth will reduce the costs and risks of a more muscular Chinese strategic policy, if not actually provoke expansion.

The Use and Limitations of History

Turning to historical analogues to understand this dynamic is irresistible for many commentators, and the value of such analogues for throwing aspects of it into relief seems undeniable. But the purpose of the present effort is analysis, not advocacy. Responsible historical analysis asks whether statesmen and policy-makers in historical circumstances could well have made better decisions, which requires identifying and weighing the crucial determinants of historical outcomes, altering the dynamics whereby they interact, and considering alternative pathways of development. It makes necessarily large assumptions about the influence of structural forces as well as the role of individual agency, and prejudicially assigns greater weight to some forms of causation than others. Those caveats underscore the limitations of reasoning by historical analogy through our current strategic dilemmas. Reasoning by historical analogy can be perilous, especially if one fails to acknowledge

that no two historical events are identical and that the future is less determinate than a linear extension of the past would suggest. The instructiveness of historical events tends to diminish the greater their distance in time and space from the day and place they occurred.[106]

The most commonly cited historical analogue to the contemporary rise of China is the ascent of Imperial Germany after 1871 and the profound shock it caused to the Metternichian balance of power in Europe.[107] The post-Napoleonic stabilization of the continent had been built upon a weak and fragmented central Europe and delicate equilibrium among the four principle powers – France, Russia, Austria-Hungary, and the British Empire. But the growth of Prussian economic power after the 1830s and Otto von Bismarck's stunning assertion of Prussian hegemony over the lesser German states altered the settlement irrevocably. That economic power expanded continually after the foundation of the German Empire in 1871 with alarming implications for the British especially, who underwent an agonizing national debate about core strategic interests and relative decline. Between 1888 and 1914, German industrial production nearly tripled as the economy achieved an average estimated growth rate of some 4.2 percent.[108] German steel production – perhaps the most useful single indicator of military productive potential in the pre-nuclear age – expanded tenfold in the same period and by 1914 exceeded that of France by a factor of four. Although German institutions translated these economic gains somewhat poorly into effective strategic power – the sore neglect of army modernization was apparent by 1912 – the country was unquestionably the most powerful in Europe by the turn of the century and was eager to claim its "place in the sun."

But German policy-makers never well understood that power in strategic terms, let alone its limitations.[109] Kaiser Wilhelm II and a succession of Imperial Chancellors squandered the precarious alliance with Russia which they had inherited from Bismarck and on which the stability of eastern and southeastern Europe had depended since 1875. Even more disastrously, they undertook a Navy program bent on developing a blue-water Mahanian fleet, even as they sought a strategic alliance with the British Empire to balance a Franco-Russian coalition after 1893. The British Royal Navy at the turn of the twentieth-century fulfilled much the same global role as the U.S. Navy today, albeit from a different impetus.[110] Of foremost concern for the British were the sea routes to markets abroad, essential for an island incapable of feeding itself since the eighteenth century. German construction of a heavy battle fleet – regardless of its supposed value for status or colonies – made impossible any accommodation with a country which viewed the

fleet as a threat to its very existence.[111] The consequence was the formation of the Entente coalition of France, Russia, and Great Britain against the encircled Dual Alliance of Germany and Austria-Hungary, and the increasingly desperate strategic position of Germany by 1908.

Even the preceding short narrative should underscore the limitations of the Anglo-German rivalry before 1914 as an analogue to the relationship between the United States and China today. The aspiring powers in each instance could not have been more different. The German Kaiserreich was demographically vigorous and nurtured a vibrant press and representative political culture after 1871, which saw the rise of the pacifistic and progressive Social Democratic movement into the largest political party in the country by 1912. In contrast, the hegemonic Chinese Communist Party oversees an authoritarian state and a society shrinking and aging at an alarming rate, a consequence of a one-child policy and economic modernization, with potentially disquieting consequences. Germany had two significant continental allies, the Habsburg and Ottoman empires, and after three years of conflict the United States joined the Allies. China today is virtually bereft of allies, with the exception of North Korea, and confronts a durable and long-standing coalition of the U.S., Japan, Australia, augmented by numerous smaller Asian partners.

An In-Depth Historical Case: Japan in the Interwar Era

A more revealing historical analogue is the US-Japanese relationship in the interwar period, when Japan practiced '*Shidehara*' diplomacy to modernize the country and grow its economy through peaceful trade.[112]The country faced profound native constraints on growth, most notably an almost wholesale dependence on foreign sources of oil, iron ore, rubber, and crucial metals for end-processing. As commercial relations yielded to the protectionist consequences of the Great Depression, Japan strove to minimize the cost of reduced trade through the construction of an autarkic East Asian empire. Therein lay the tragic dilemma. Japanese leaders were well aware that if they expanded to compensate for losses in trade, they would increase mistrust of Japanese intentions and provoke further trade restrictions. But they also came to feel that had little choice but to risk war, given Japan's inability to survive economically as a small island state in a world of large and increasingly closed economic systems.[113]The U.S. imposed high sanctions in retaliation to Japanese expansion, and Japanese leaders eventually reasoned – as their prospects for better trade relations

evaporated – that they had no better option than war. The policy was deeply controversial at the highest levels of state, and the emperor was compelled to intervene against hard-line sentiment. Civilian officials, particularly in the foreign ministry, favored security through expansion – even at the risk of war with the U.S. – at least as vehemently as did senior military officers.[114] The fact that the country risked war as the better of two troubled options illustrates how states dependent on trade to support core interests may well embrace the risk of a war that they have little hope of winning.[115]

Conventional interpretations of Japanese policy in the interwar period center on unbridled militarism.[116]In this view, as the Japanese strategic outlook deteriorated, the military gained the high ground in policy debates and high-jacked them for its own aims. Civilian leaders who might have moderated policy were marginalized. But a generation of academic research has unwound that conventional view. Civilian intervention in strategic policy debates against the military – with the backing of the emperor –increased as Japan moved closer to war with the United States from 1938 to 1941. Moreover, the military was not always the strongest proponent of war.[117] The foreign ministry frequently adopted a harder line than the navy – long thought to the chief advocate of aggressive expansionism – while by 1940–41, almost all civilian leaders understood the grim consequences of U.S. sanctions and embraced the risks of war. A series of so-called "Liaison Conferences," involving both military and civilian officials, starkly clarified the hazards and costs of such a war and yielded an overarching consensus in favor of it.

The brute fact driving the deliberations of Japanese officials was that the resources necessary for the nation's modernization drive, initiated in 1857, lay beyond its borders. Successive governments had understood security to require economic growth and a strong military, both in support of cautious territorial expansion when necessary. What differentiated the Shidehara diplomacy of the 1920s from later policies were not the ends, but the means. Japanese officials understood an emphasis on growth through peaceful trade to be different from expansion through conquest, which presented considerable risk and costs. The problem was that the limits of peaceful growth were fast approaching by the 1930s. The conquest of Korea and Taiwan – tolerated by the western powers – enhanced Japan's agricultural self-sufficiency somewhat but brought little further value. Japan was almost entirely dependent on trade with U.S. and European powers for industrial commodities and raw materials: America for oil and iron ore, and British

Malaysia, French Indochina, and Dutch East Indies for rubber, oil, tin, tungsten, and other minerals. Japan cultivated trading relationships with those countries in the 1920s and pursued cautious, accommodationist policies. But the domestic responses of the western powers to the Great Depression and the consequences for continued Japanese growth spurred an unavoidable shift.[118] U.S. and European trade restrictions weakened the argument that economic growth through trade was the best route to Japanese power and security. And pessimistic expectations for future growth lowered the value of trade, making military options more attractive.

Of course, the secular strategic advantages of the other major Pacific powers also factored into Japanese thinking. The country's officials watched the menacing growth of the Soviet Union and the United States with alarm. Both countries commanded enormous domestic markets and resource bases, and could weather a downturn in international trade through autarky alone, further hastening the decline in Japan's relative strategic position. Rather like the long tradition of strategic thinking among officials in Germany in the pre-nuclear era, the Japanese government arrived at the desperate conviction that only a territorially expansive, self-sufficient economic empire could ensure the country against the other powers. After 1932, Japanese leaders resolved to incorporate East and Southeast Asia – by peaceful means if possible, by force if necessary – to provide the commodities and raw materials essential for national survival.

Crucial here is the context of poor international trade prospects for hard-liners in Japanese policy debates. Such voices are often present in arguments over the comparative advantages of trade and conquest, but are often marginalized by circumstances advantageous for peaceful growth and security. From 1934 to 1937, the influence of those who favored a military solution to the Japanese dilemma – military and civilian alike – rose appreciably.[119] Although the Japanese Navy had strong reservations about provoking the United States, senior officers reluctantly agreed that the country had no choice but to dominate Asia economically. Admiral Koshirō Oikawa, a member of the moderate Treaty Faction in the Imperial Naval Staff who argued that Japan could not afford an arms race with the western powers and pushed for a restoration of the Anglo-Japanese Alliance, argued that Japan should expand north first, develop Manchuria, and then turn south:

> "No problem would arise if we [could proceed]... peacefully in all directions, but when the powers are raising high tariff

> barriers as they are today and are preventing artificially the peaceful advance of other countries, we must of necessity be prepared and determined to use force in some areas and eliminate the barriers."[120]

Unfortunately, complete self-sufficiency – the object of the autarkic impulse – is nearly impossible to satisfy fully. As long as Japan obtained petroleum, rubber, and scarce metals through trade with the United States and the colonial territories of southeast Asia, national policy focused on matters other than expansion. But overshadowing Japanese concerns was the awareness that deterioration of relations with the U.S. would place the readiness of the navy at risk, as fuel for ships and naval aircraft became scarcer. The Japanese Navy established the "Committee to Investigate Southern Policy" in July 1935, chaired by Vice Chief of Staff Shimada Shigejiro, to assess the petroleum resources of southeast Asia and weigh their value against the risk of war with the United States.121In April 1936, Fleet Admiral Osami Nagano, the Navy minister, argued that the inadequacy of petroleum resources in Manchuria necessitated a push into the Dutch East Indies, leading to a consensus "to advance and develop in the Southern area." Although the Japanese military began to plan specific campaigns along those lines, they remained contingencies, and expansion southward was still to be "by gradual peaceful means," to avoid alienating the West and sparking outright conflict.[122]

In June 1938, Washington initiated the first in a series of punitive sanctions with a "moral embargo" on military equipment, provoking an immediate Japanese declaration that the country must strive for economic self-sufficiency.[123] In April 1939, the navy drew together its analysis and advocacy into its "Policy for the South," a program built on a lengthy history of Japanese strategic thought and which argued for the seizure of "materials necessary to promote productive capacity" at home.[124] None were more important than petroleum. Japan depended on the United States for eighty percent of its oil, and a domestic program to produce synthetic substitutes had failed miserably. In July 1939 the U.S. government announced that it would not renew the 1911 trade treaty, which stimulated Japanese plans to seize the Dutch East Indies and its oil and rubber resources. Even the Japanese Army, long a staunch supporter of primary expansion into Manchuria, now abandoned that program and backed the southern strategy. Senior Japanese naval leaders again pointed out the major risks of war with the United States, but emphasized that no good alternative remained and that the moment was ripe for

"positive steps" to set the country's modernization on a firmer basis. That same month the U.S. government halted transfers of scrap iron and aviation fuel, a measure described by the Japanese navy leadership as "a matter of life and death for the empire" and a pretext for the seizure of French Indochina. This was undertaken with full awareness of the consequences, but from the conviction that further embargoes would be ruinous.

Japanese strategic prospects had become a vicious spiral. Passivity meant that Japan would find it difficult – if not impossible – to secure the resources for further modernization and growth, exacerbating the country's relative decline.[125]At an Imperial Conference in September 1940, Prime Minister Fumimaro Konoe pointed out that "[w]e can anticipate that trade relations with Britain and the United States will deteriorate even more. If worst comes to worst, it may be impossible to obtain any imported goods.[126] "If Japan sought to provide for its growth through war and expansion, the U.S. would tighten its embargo and squeeze the country into submission. By April 1941, the army and the navy reiterated that Japan would have to resort to military force "if the empire's self-existence is threatened by embargoes.[127] "The most serious embargo came at the end of July 1941, when the U.S. government froze Japanese assets and ended shipments of oil.[128] Earlier that month, Japanese leaders had argued in Liaison Conferences that the country should again attempt to increase trade with the United States by any means. But with a comprehensive trade embargo looming, the leadership now felt that it faced an intractable situation.[129] Japan was declining relative to other Pacific powers, argued Navy Chief of Staff Nagano. Temporary military superiority in the western Pacific made feasible a short and decisive military offensive to seize the necessary resource base. The U.S. would presumably recognize no Japanese threat to its core national interests, and judge the costs of suppressing the Japanese unreasonably high. Better the risks and uncertainties of such a war, Nagano argued, then a slow and inevitable decline.

This view underlay the critical Imperial Conference of 6 September 1941, when military and civilian leaders presented Hirohito with a consensus plan to restore commercial relations with the U.S. and Great Britain and secure "those goods from their territories in the South West Pacific that our empire urgently needs to sustain herself."[130] The emperor managed to extract the cabinet's assurance that all prospects of solving the crisis through diplomatic means would be exhausted, but subsequent negotiations with Washington went poorly. The U.S. insisted that the Japanese turn away from China, while the Japanese resolutely

refused to abandon their gains on the mainland. In the historic conference of 1 November, despite the army's plea for immediate war, senior officials determined to extend negotiations until November 30. According to army Vice Chief of Staff Tsukada Osamu, “[i]n general, the prospects if we go to war are not bright. We all wonder if there isn't some way to proceed peacefully....On the other hand, it is not possible to maintain the status quo. Hence, one unavoidably reaches the conclusion that we must go to war.” At the final peacetime Imperial Conference on 1 December, Foreign Minister Togo explained that acceptance of U.S. demands, including the insistence that Japan withdraw its forces from China and French Indochina, would mean that "our very survival would inevitably be threatened." The president of the Privy Council, speaking for the emperor, resigned himself to the inexorable logic of the Japanese strategic position: "[It] is clear that the existence of our country is threatened, that the great achievements of the Emperor Meiji would all come to naught, and that there is nothing else we can do.”[131] Six days later, the Japanese government launched a war which few believed it could win, but without which the country was thought to have little prospect of an autonomous destiny.

For three-quarters of a century, Japanese leaders pursued a policy of economic growth and modernization through trade, a decision which led them – like China today – into a state of aggravated dependence on foreign markets and on foreign sources of resources and commodities. The strategy worked extraordinarily well, at least until exogenous economic forces radically changed the structure of international trade and isolated Japan from its chief inputs and outlets. The Great Depression drove the U.S. and European powers to protectionist economic regimes, which Japanese officials understood as leading inevitably to their country’s relative strategic decline. Security, economic growth, and quite possibly national survival were thought to be risk. By late November 1941, officials viewed the incalculably high risks and costs of war as preferable to strategic decline.

Reasoning from the Historical Case to China Today

At the helm of an economy heavily dependent on access to imported resources and overseas financial and export markets, contemporary Chinese leaders face a growth and modernization dilemma roughly analogous to that of Japan in the interwar period. Were trade with the outside world – particularly the U.S. – to contract drastically, Chinese leaders might well reason that an economic policy based on more direct

influence over critical resources, if not outright control over them, is essential to sustain growth, modernize the economy and military, and safeguard the stability of the regime. Such a course would lead at the very least to profoundly different diplomatic and economic alignments than have sustained the U.S. geostrategic position in Asia for decades, and in the worst case place China on a path to potential conflict with the United States

China's success in overcoming the financial crisis and its large dollar reserves have led some to suggest that the country enjoys leverage over U.S. policy greater than any the U.S. could muster against China. However, a balanced perspective weighs the overall relationship between strategic power and economic and financial interdependence, which involves short-run sensitivity and long-term vulnerability.[132] Sensitivity refers to the level and pace of the mutual dependence, or the rapidity with which an alteration in one part of the system brings about changes in another. In an era of deeply interconnected capital markets, it has become axiomatic that stress in financial institutions in one part of the world can have consequences elsewhere, sometimes highly nonlinear. Sensitivity, however, is different from vulnerability, which refers to the relative costs of changing the structure of a system of interdependence and which is thought to exert more power in relationships than does sensitivity. The less vulnerable of two countries is not necessarily the less sensitive, but rather the one that would incur lower costs from altering the situation. In the 1980s, when President Ronald Reagan cut taxes and raised expenditures, the United States depended heavily on imported Japanese capital to balance the federal budget, and Japan enjoyed some measure of leverage over the United States.[133] But Japan's economy was slightly more than half as large as U.S. economy, and the Japanese arguably needed the U.S. export market more than the United States needed Japan. Without attractive growth prospects elsewhere for capital investment, Japan would hurt itself more than it would the United States if it stopped lending to the U.S. government. Likewise, the United States was sensitive but not vulnerable to East Asian economic conditions in 1998. The financial crisis there cut half a percent off the U.S. growth rate, but with a booming economy the United States could absorb the reduction and continue to grow. Indonesia, on the other hand, was both highly sensitive and vulnerable to the changes in trade and investment patterns that the 1998 crisis unleashed. Its economy suffered severely, leading in turn to internal political conflict. Both sensitivity and vulnerability point to a third aspect of an interdependent relationship. Symmetry refers to situations of relatively balanced, as opposed to

asymmetric or unbalanced, dependence. If one of two interdependent countries is less so than the other, it enjoys a notable source of leverage as long as the other values the relationship.[134] Manipulating the asymmetries of interdependence has long been an important and effective dimension of U.S. economic and diplomatic power.

Just such a dynamic has developed between the United States and China. Consumers in the U.S. pay for Chinese imports in dollars, and China either holds U.S. dollars and bonds – in effect making a loan to the U.S. – or invests them in tangible assets in the U.S. or abroad, enhancing the value of those assets. Through this mechanism, China has amassed vast foreign exchange reserves, much in the form of U.S. Treasury securities, and considerable asset holdings. Believing that China could bring the United States to its knees through dollar divestiture, some have described the current relationship between the two countries as an asymmetric shift in the global balance of power. But divestiture would also reduce the value of Chinese reserves as the value of the dollar fell and jeopardize U.S. willingness and ability to import Chinese goods, leading to economic contraction and instability in China. Assessing the strategic character of the relationship between the U.S. and China as a function of economic interdependence depends on the balance of asymmetries, and not the impact of discrete policy alternatives on one side of the equation. In February 2010, a group of senior Chinese military officers called for their government to sell off U.S. government bonds in retaliation against U.S. arms sales to Taiwan.[135] In reply, the director of the Chinese state's foreign exchange administration acknowledged the intertwined interests of each party, calmly explaining that "Chinese investments in U.S. Treasuries are market investment behavior and we don't wish to politicize them."The most accurate characterization of the strategic dynamic between the U.S. and China is that they currently operate within a "balance of financial terror" analogous to the military interdependence (mutually assured destruction) of the U.S. and the Soviet Union during the Cold War, wherein each cultivated the potential to annihilate the other in a nuclear exchange.[136] Instead of physical annihilation, the two countries emphasize the capacity to wreck the economic growth and productivity on which – asymmetrically – the stability of both governments and the livelihoods of both populations are thought to depend.

So understood, the present balance – dependent as it is on complex factors often exogenous to the discretion of both governments – does not guarantee stability. Not only is there the perennial danger of miscalculations on both sides about the intentions and vulnerabilities of

the opposite party, but each has a strong interest in altering their exposure to the relationship and reducing their vulnerabilities. After the 2008 financial crisis, the United States pressed China to float its currency upward to reduce the U.S. trade deficit and dollar imbalance. At the same time, China's Central Bank pushed the United States to increase its domestic rate of savings, reduce its government deficits, and accept that the dollar should eventually be supplemented by the International Monetary Fund (IMF) issuing special drawing rights as a reserve currency, or replaced by a basket of weighted currencies.[137] But while China has grown strong enough to push against U.S. appeals, it has yet to have meaningful effects on U.S. policies. And while China reduced its dollar reserves somewhat, domestic political tensions have made the government unwilling to risk making the Yuan fully convertible and pushed even further into the future any possibility of it replacing the dollar as an international reserve currency. But the Chinese appear willing to take the long view and work strategically to increase domestic consumption, expanding the middle-class and decreasing the importance of the U.S. market as the engine of growth. It has also drawn financially troubled authoritarian states into a state of increased dependence on its own lending as a guarantor of stability. The internal stability of the Chinese regime will presumably come to depend gradually on factors other than the economically interdependent relationship with the United States.

That said, the evolving strategic balance between the U.S. and China still reflects the evolving asymmetries of economic interdependence. While neither the United States nor China is directly unwinding the ties that bind them, the United States has specifically abetted growing Chinese influence in numerous international contexts, such as the IMF, the World Bank, and especially in the G-20, which represents some 80 percent of world product.[138] Such meetings have discussed the need to ''rebalance'' financial flows, altering the old pattern of U.S. deficits matching Chinese surpluses. Such changes would require shifts in domestic patterns of consumption and investment that would be politically difficult in both countries, with the United States increasing its savings and China floating the Yuan and increasing domestic consumption. Moreover, as other developing economies, such as India and Brazil, struggle to export against an undervalued Chinese currency, they may come to see value in reinforcing the U.S. position against China in multilateral talks, like the G-20. One should expect each side to tack and weave within the context of their economic interdependence to

lessen its vulnerability and shape the larger structure of the strategic environment.

Of course, in its implications for the future economic interdependence of the U.S. and China, the historically unprecedented element is the nuclear arsenal that each side possesses. Nuclear weapons enormously complicate the calculus for assessing the costs and risks of war and diminish the usefulness of historical analogy with either the Anglo-Germany rivalry after 1890 or U.S.-Japanese tensions in the 1930s. There can be little doubt that current U.S. superiority in nuclear and conventional military power has a restraining effect on Chinese decision-making, while the inherent limitations of conventional alternatives in the 1930s gave Japan measurably greater confidence in its expansionist strategy. But the structural similarities between the historical moments are otherwise revealing, and one dismisses only foolishly their key implications, namely the potential for military conflict deriving from the heavily interdependent relationship between the U.S. and China. It is not through blind ambition that China has worked to project military influence into the South China Sea, influence the distribution of the area's promising oil and gas reserves, and safeguard crucial trade links to world markets and resources. As growing competiveness diminishes expectations of gains through trade and cooperation, a sphere of economic influence in Asia – based on more or less subtle forms of hegemonic influence if not outright control – will become essential to the political and social stability of the Chinese regime and the country's national security. Chinese measures – undertaken on entirely predictable pretexts – will increase the likelihood of direct, zero-sum rivalry and even war. The basic logic for how economic interdependence and strategic power interact to shape the probability of war remains compelling.

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[91]Robert Keohane and Joseph Nye, *Power and Interdependence* (Glenview, 1989) p.261.

[92] [RAND] China's economy is expected to grow at roughly twice the rate of the American over the next fifteen years. At market exchange rates, China's GDP is about 40 percent of the US GDP, and RAND estimates that by 2025 it will be about half. China currently commits about 2.5 percent of its GDP to defense expenditures, roughly half the current American rate. Although Chinese defense spending has risen significantly in recent years, keeping pace with and even exceeding overall economic growth, the US defense budget has, since 2001, grown even faster. Thus in 2000 the US defense budget was seven times that of China, and in 2010 it was ten times bigger. As the wars in Iraq and Afghanistan wind down, the US rate of spending is likely to decrease, although probably not to Chinese levels. By 2025, RAND estimates that Chinese defense spending will probably be somewhat more than half of America's. Of course, all Chinese defense spending will be focused on the Western Pacific, whereas only a fraction of America's will be relevant to that region.
These figures are much disputed in both the academic and intelligence communities. They rest on current trends extrapolated far into the future. Using purchasing power parity rather than market exchange rates, China catches up to and surpasses the United States much more quickly. Purchasing

power parity is a better reflection of personnel costs, while market exchange rates better capture equipment costs, particularly high-tech equipment, which tends to be the area of US-Chinese competition of most concern to the United States.

[93] On the broader validity of measurement claims, see Linyue Li, Nan Zhang, and Thomas D. Willett, "A Survey of Measurements of Interdependence," Research Paper, Claremont Institute for Economic Policy Studies, October 15, 2011; since 2000, the US trade deficit with China has increased to almost 2 percent of US gross domestic product. Claims of increasing interdependence are arguably spurious if the trade accounted for "fails to identify the contribution of different countries in the intermediate production of the final good and is not representative of actual interdependence." Instead of allocating the full value of a finished product to the country from which it was delivered, some economists argue that trade data should assign value on a value-added basis; that is, the final value should be divided into its various parts, each representing "the amount by which the value of a good or service increases at a specific step in a production process." Unfortunately, tracking the value added by each country involved in the production of a good is difficult, if not impossible: Michael Sposi and Janet Koech, "Value-added Data Recast the US–China Trade Deficit," *Economic Letter*, Federal Reserve Bank of Dallas, July 2013.

[94]United States Census Bureau, US Department of Commerce, "Foreign Trade: Trade in Goods with China,"http://www.census.gov/foreign-trade/balance/c5700.html#2013.

[95]International Monetary Fund, *International Financial Statistics* 53, no. 11(Washington, D.C., 2000) pp.228-30; even more poignant, perhaps is the fact that the country's trade grew from a mere $21 billion in 1978, at the beginning of reforms, to$360 billion by 1999, an increase possibly without precedent in world history. By 1997, China had accumulated more than $130 billion in foreign currency reserves, but also had an external debt of $120 billion. See IMF, *International Financial Statistics*, p. 228.

[96]Marc Labonte and Jared Nagel, *Foreign Holdings of US Debt*, CRS Report RS33251 (June 24, 2013); foreign holdings of US debt are tabulated in US Treasury Department, "Major Foreign Holders of Treasury Securities," at http://www.treasury.gov/resource-center/data-chart-center/tic/Documents/mfh.txt;.

[97] Open Doors Data, US Study Abroad, http://www.iie.org/Research-and-Publications/Open-Doors/Data/US-Study-Abroad: and Leading Destinations, Educational Exchange Data, Institute of International Education, http://www.iie.org/~/media/Files/Corporate/Open-Doors/Fact-Sheets-2013/Country/China-Open-Doors-Fact-Sheet-2013.ashx.

[98] The best introductory surveys of this issue are Mark J.C. Crescenzi, *Economic Interdependence and Conflict in World Politics* (Lexington Books, 2005); and Edward Mansfield and Brian Pollins, "Interdependence and Conflict: An Introduction," in Mansfield and Pollins eds., *Economic Interdependence and International Conflict: New Perspectives on an Enduring Debate* (Ann Arbor, 2003) pp.1-30.

[99] Xi Jinping, Speech at the National Committee on US-China Relations and US-China Business Council Luncheon, Washington, D.C., 15 February, 2012: http://www.ncuscr.org/programs/luncheon-honor-vice-president-xi-jinping; and Hillary Rodham Clinton, Remarks at the US Institute of Peace China Conference, US Institute of Peace Washington, DC, 7 March, 2012: http://www.state.gov/secretary/20092013clinton/rm/2012/03/185402.htm.

[100] "Leaders work for a stable world," *China Daily Europe*, 18 March 2013: http://europe.chinadaily.com.cn/china/2013-03/18/content_16315037.htm.

[101]John J. Mearsheimer, "Disorder Restored," in Graham Allison and Gregory F. Treverton, eds., *Rethinking America's Security* (New York, 1992) p.223.

[102] Daniel Yergin, *The Prize: the Epic Quest for Oil, Money, and Power*(New York, 1991) p.24.

[103]Kenneth Waltz, *Theory of International Politics* (New York, 1979) p.106; idem, "The Myth of National Interdependence," in Charles Kindleberger,ed., *The International Corporation* (Cambridge, 1970) pp.205-223.

[104] Robert Gilpin, *The Political Economy of International Relations* (Princeton, 1987) p.58.

[105]David Scott, *China Stands Up: the PRC and the International System* (New York, 2007) p.162.

[106]Richard E. Neustadt and Ernest May, *Thinking in Time: The Uses of History for Decision Makers*(Boston: Simon and Schuster, 2011).

[107] Easily the most thoughtfully cautious are James R. Holmes and Toshi Yoshihara, "History Rhymes: The German Precedent for Chinese Seapower," *Orbis* 54:1(2010) pp.14-34; and Douglas C. Peifer, "China, the German Analogy, and the New AirSea Operational Concept," *Orbis* 55:1(2011) pp.114-131; less so, and typically political scientific is Reinhard Wolf, "Rising Powers, Status Ambitions, and the Need to Reassure: What China Could Learn from Imperial Germany's Failures," *The Chinese Journal of International Politics* 7:2 (2014) pp.185-219.
[108] Estimating the absolute economic growth of any nation before the 1950s is thorny, and the reader should grant the present analysis an appropriate measure of latitude. The fundamental macroeconomic analysis here is Walther G.Hoffmann, Franz Grumbach, and Helmut Hesse. *Das Wachstum der deutschenWirtschaftseit der Mitte des 19.Jahrhunderts* (Berlin: Springer, 1965).
[109] The best synthesis of German strategic bankruptcy after 1890 remains Imanuel Geiss, *German Foreign Policy, 1871-1914* (London/Boston, 1976).
[110] See Corbett's brilliant assessment of the strategic situation in his post-war *History of the Great War Based on Official Documents: Naval Operations* (London: Longmans, Green and Co.,1920) pp. 1-18.
[111] Paul M. Kennedy, *The Rise of the Anglo-German Antagonism, 1860-1914* (Boston: Allen & Unwin, 1980) pp.265ff..
[112]W. G. Beasley, *Japanese Imperialism* (New York: Oxford University Press, 1987: a good introductory survey of the transitional moment is Saitō Takashi, "Japan's Foreign Policy in the International Environment of the Nineteen-Twenties," *The Developing Economies* 5:4 (1967) pp.685-700.
[113] As captured by the slogan that defined the elite's objectives since the Meiji restoration: "rich country, strong army:"Kaoru Sugihara, "The Economic Motivations behind Japanese Aggression in the late 1930s: Perspectives of Freda Utley and NawaToichi," *Journal of Contemporary History* (1997) pp.259-280.
[114]Sadao Asada, "Between the Old Diplomacy and the New, 1918–1922: The Washington System and the Origins of Japanese-American Rapprochement," *Diplomatic History* 30:2 (2006) pp.211-230.
[115] The following is based on Dale C. Copeland, "Economic Interdependence and War: A Theory of Trade Expectations," *International Security* 20:4 (1996) pp.5-41; and idem, "Economic Interdependence and the Future of US-Chinese Relations," in G. John Ikenberry and Michael Mastanduno, eds. *International Relations Theory and the Asia-Pacific* (Columbia University Press, 2003) p.323.
[116] A statement of it is found in Jack Snyder, *Myths of Empire: Domestic Politics and International Ambition* (Ithaca: Cornell University Press, 1991).
[117] The emperor's crackdown on the radical right after the failed coup attempt in February 1936 greatly reduced the pressure they could bring to bear on strategic policy: see Edward Behr, *Hirohito: Behind the Myth* (New York: Vintage, 1989).
[118] See the final chapter of Akira Iriye, *After Imperialism: The Search for a New Order in the Far East 1921-31* (Chicago: Imprint, 1990).
[119]Michael A. Barnhart, *Japan Prepares for Total War: The Search for Economic Security, 1919–1941* (Ithaca: Cornell University Press, 1987) p. 37.
[120]Stephen E. Petz, *Race to Pearl Harbor The Failure of the Second London Naval Conference and the Onset of World War II* (Cambridge: Harvard University Press, 1974) p. 170; Oikawa's futile efforts to accentuate the value of improved relations are noted in Sadao Asada, *From Mahan to Pearl Harbor: The Imperial Japanese Navy and the United States* (Annapolis: Naval Institute Press, 2013) pp.250-3.
[121]Asada, *From Mahan to Pearl Harbor*, pp.206-7.
[122]James B. Crowley, *Japan's Quest for Autonomy: National Security and Foreign Policy, 1930-1938* (Princeton: Princeton University Press, 1966) pp.288, 299.
[123] Basic is Edward S. Miller, *Bankrupting the Enemy: the US Financial Siege of Japan before Pearl Harbor* (Annapolis: Naval Institute Press, 2007);a fine survey of the embargo process, albeit marred by an incoherent analysis is Chihiro Hosoya, "Miscalculations in Deterrent Policy: Japanese-US relations, 1938-1941," *Journal of Peace Research* 5:2 (1968) pp.97-115.

[124]Dale C. Copeland, "A Tragic Choice: Japanese Preventive Motivations and the Origins of the Pacific War," *International Interactions* 37:1 (2011); from Joyce C. Lebra, ed. *Japan's Greater East Asia Co-Prosperity Sphere in World War II: Selected Readings and Documents* (Kuala Lumpur: Oxford University Press, 1975) p. 62.
[125] Depicted well in Copeland, "A Tragic Choice," pp.116-126.
[126]NobutakaIke, ed. *Japan's Decision for War: Records of the 1941 Policy Conferences* (Palo Alto: Stanford University Press, 1967) p.5.
[127] The entire transcript is featured in Morley, James William, ed. *The Fateful Choice: Japan's Advance into Southeast Asia, 1939-1941* (New York: Columbia University Press, 1980) pp.303-4.
[128]James H. Herzog, "Influence of the United States Navy in the Embargo of Oil to Japan, 1940-1941,"*The Pacific Historical Review* (1966) pp.317-328.
[129]Peter Wetzler, *Hirohito and War: Imperial Tradition and Military Decision Making in Prewar Japan*(Honolulu: University of Hawaii Press, 1998) p.37-49.
[130] Ike, *Japan's Decision for War*, p.135.
[131] Dale C. Copeland, "Economic Interdependence and the Grand Strategies of Germany and Japan, 1925-1941," in Jeffrey W.Taliaferro, Norrin M. Ripsman, and Steven E. Lobell, eds. *The Challenge of Grand Strategy: The Great Powers and the Broken Balance Between the World Wars* (New York: Cambridge University Press, 2012) p.143.
[132]So characterized originally in Keohane and Nye, *Power and Interdependence*, pp. 3-32; with greater acuity in Mark J. C. Crescenzi, *Economic Interdependence and Conflict in World Politics* (Lexington, 2005) pp.28-9.
[133] See Albert Ando and Alan J. Auerbach, "The Cost of Capital in the United States and Japan: A Comparison,"*Journal of the Japanese and International Economies* 2:2 (1988) pp.134-158.
[134]Kal J.Holsti, "A New International Politics? Diplomacy in Complex Interdependence," *International Organization* 32:02 (1978) pp.513-530; note the dynamics, for example, in Tom Casier, "Russia's Energy Leverage over the EU: Myth or Reality?," *Perspectives on European Politics and Society* 12:4 (2011) pp.493-508.
[135]Daniel W. Drezner, "Bad Debts: Assessing China's Financial Influence in Great Power Politics," *International Security* 34:2 (2009) pp.7-45; also Daniel H. Rosen and Thilo Hanemann, *China's Changing Outbound Foreign Direct Investment Profile: Drivers and Policy Implications*, No. PB09-14 (Washington, DC: Peterson Institute for International Economics, 2009); and Benjamin J. Cohen, "Sovereign Wealth Funds and National Security: the Great Tradeoff," *International Affairs* 85:4 (2009) pp.713-731.
[136] A term devised by Lawrence H. Summers: "The United States and the Global Adjustment Process." Speech given at the Institute for International Economics, Washington, D.C., March 23, 2004.
[137] The issue is well rehearsed in Ronald McKinnon and Gunther Schnabl, "The Case for Stabilizing China's Exchange Rate: Setting the Stage for Fiscal Expansion," *China & World Economy* 17:1 (2009) pp.1-32; and idem, "China and Its Dollar Exchange Rate: A Worldwide Stabilizing Influence? "*The World Economy* 35:6 (2012) pp.667-693.
[138]See G. John Ikenberry, "The Rise of China and the Future of the West: Can the Liberal System Survive?," *Foreign Affairs* (2008) pp.23-37; Daniel W. Drezner, " The New New World Order," *Foreign Affairs* 86 (2007) p.34; and Gregory Chin and Ramesh Thakur, "Will China Change the Rules of Global Order?," *The Washington Quarterly* 33:4 (2010) pp.119-138.

Chapter 4

Strategic Scenario Planning

A2AD scenarios are an assembly or series of possibility states that can be examined in deliberate ways in an on-going strategic conversation. Scenario planning brings unique value through insights gathered from *game play*, especially in the absence of clear facts or certainty about the future, and specifically in the face of complex, volatile and adaptive circumstances between nation states or unassociated actors. Scenarios are setup to formulate hypotheses, tests, exploration, and interactions among many stakeholders, for the purpose of analyses. Emergent and reoccurring signals generated from game-play will enhance vision and direction of plans (such as through the development of branches and sequels or contingency planning) to the careful observers and listeners. The goal is to differentiate evanescent trends from true and recurrent challenges in the face of tough and emergent choices. The goal is for A2AD scenarios to bring forth new insights before a military is put to the test and before the enterprise is bent to support it.

Giving attention to potential trends, tensions, escalation criteria and friction points uncovers sets of possibilities for game-play of this sort. Examination of rational and irrational "choices under circumstances" and the use of executable strategies is one bridge that links to foresight. In reconciling, weighting, and comparing the use of real-world technologies and measures within strategic scenarios, situational experimentation can be conducted and addressed, which may reveal decision making patterns and correlations from multiple stakeholders and multiple iterations of game play. *These patterns are useful in forming robust and resilient concepts which can guide policy, economic strategies, and other technical or operational military constructs – at several levels – from DoD to NAWCAD*.

Simply stated, the ramifications of decisions should be considered as early and as broadly as possible to encourage a collaborative learning-orientation for an organization. Alternatives can be shaped in leaders' minds well before short-term situations pop-up and make reflection impossible. In this sense, NAWCAD decision makers stand to greatly benefit from testing concepts against A2AD scenarios, for example through the assembly of many thoughtful perspectives and the examination of decision making under the pressure of undesirable, but real-world tradeoffs. Scenarios allow humans to adapt within the context of the scenario so that choices can be examined more fully, which can

inform thoughtful policy and future decision making. In this case, A2AD represents a VUCA environment with much uncertainty, yet "chance favors the prepared mind" (Louis Pasteur). This is the art of the scenario and the art of the long-view.[139]

This unclassified study focuses on thought experiments and game-play for multiple audiences of A2AD - including institutions such as NAWCAD. Moreover, the critical focus on the economic, technological and military elements of national power may influence strategic enterprise perspectives and outcomes. As highlighted in Chapters Two and Three, ETC's research team identified specific economic influences with a focus on A2AD, including both micro- and macro-economic elements of power worth examining. For example, insights into historical foundations of national power were examined. Historical and economic constructs were highlighted as scenario background to provide worldwide interactive context as the backdrop for A2AD scenarios. Perspectives on war emerge from decision points held against these historical interactions and economic facets of national security, especially when state-level conflict is "played" at theater scales. These contextual elements of scenarios are like rheostats and potentiometers that can be dialed for various levels of initial conditions that set the stage for game-play. Of course multiple iterations and resets are allowed and in fact encouraged for the purpose of studying decision making and choices that can be analyzed.[1]

Scenarios divulge clues and indicators for how future power might be employed (whether plausibly or haphazardly employed). Scenarios also provide insights into how investments might be prioritized as a consequence of desired results. The most useful scenarios are the ones

[1] The level and character of risk are debated at strategic, operational and even tactical scales and this debate is neither exhausted nor resolved in this study. Additionally, nothing published herein is of a classified nature, and the opportunity exists to advance this study to the classified realm to add to the learning derived from scenarios of this sort. In fact, there are many areas exposed herein that reflect various viewpoints on a multitude of subjects, however this study's focus is mainly at the intersection of military, technological, and economic elements of national power. In this regard, the confluence of these three factors sheds new light on the subject of A2AD for the institutions of the U.S. Navy, through various contextual lenses. Moreover, this study seeks to uncover and expose risk and possible solutions for the United States Navy and its supporting institutions, such as NAVAIR and NAWCAD.

that are credible, yet, 'stress' the institution's capacity to act if and when it is pressed when action is required. In this light, A2AD represents one of only a few strategic scenarios that scale in both tactical and operational ways. A useful series of simulations can unveil "levers" – or strategic points of pressure – these levers in turn yield unique advantages and indicate critical areas for contingency plans and fail-safes. Scenarios also uncover potential designs for offsetting strategies or technological strategies that precipitate credible deterrence.

Furthermore, where the U.S. military is challenged, the Navy's enterprises such as NAWCAD will also be challenged. For example, NAWCAD as a federal laboratory will be required to answer the call for innovation in technology, shifting strategic human capital and a call for fleet support. In that light, the examination of A2AD as an influencer is a smart undertaking at all levels of U.S naval activity, including NAVAIR, NAVSEA and SPAWAR, who are all concerned with the advent of new A2AD technologies, including their transition into meaningful foreign service.

A2AD Scenario Development

The U.S. has historically operated forward, on patrol, accessing the commons at will. In a nutshell, foreign A2AD capabilities represent a very challenging prospect for the U.S. forces that operate forward and abroad, and in particular to the U.S. Navy who remains on continuous patrol overseas. While the U.S. continues a long standing tradition of forward presence, the U.S. has also traditionally maintained power projection at the ready wherever it travels. A2AD scenarios represent a clear and present risk to both U.S. operations and power projection capabilities, and take into account U.S. Navy and U.S. Air Force forward force postures and capacities.

When grappling with the intricacies of visible foreign military preparations worldwide, one can conjure up many purposeful thought experiments. The first endeavor before designing that game is to understand what one wants to learn in playing the game. Incorporating modeling and simulation criteria can then be conducted with the assembly of situational trends on the world stage, so that inter-play can be put together that tests the full mettle of a force. The best part about simulations in the age of computing is that many disparate scenarios can be played simultaneously and in parallel, and with the help of supercomputing, many can be played quickly with slight variations. Considerations for the defense planner can range from the reasonable to

the unreasonable, from the rational to the irrational, and from the historic to the future philosophical.

In the end, game-play experiments and iteration offers a reviewable set of decision points for a range of would-be situations that adversaries with A2AD measures might use against the U.S. The outputs of the game are possible strategic inflection points and opportunities (technical, military or even other elements of national power) that are in need of further exploration. Further exploration in turn can lead to patterns and correlations in decision making, which can lead to robust and resilient defense technology strategies, requirements for a future technological workforce, and the processes for the institution to undertake in order to acquire both successfully.

It is noteworthy however, to understand that A2AD is neither a new philosophy nor an exclusive philosophy to any particular region of the world. Tangredi points out a most important historical perspective about A2AD thinking when he states:

> "However, in addition to A2AD being modern terms and strategic challenges, [it] constitutes an ancient concept – they are techniques of strategy that have been used throughout military history. They are also historical components of grand strategy."[140]

Many nations with smaller and less technologically able militaries have taken note of historical operational successes via A2AD measures that thwarted access and operations. From an offensive perspective, operational access can be thought of as the ability to project military force into an operational area with sufficient freedom of action to accomplish the mission[141]. To visualize a potential adversary's "moves" against U.S. access from a defensive planning perspective is to change one's reference frame "inside-out," and "red-team." Red Team reveals insights into how one might defend against a nation that seeks operational access. A2AD is one such opportunity that is affordable and controllable for a smaller or less capable nation.

Adjusting one's thinking to "red-teaming," opens new outlooks on U.S. national security in terms of critical vulnerabilities for operational access. Red-teaming yields foresight and vision in doing so. A full examination of the range of possibilities for ones adversary, no matter how grave, reveals opportunities for "blue" preparation and action. In the ongoing strategic conversation these "red-team" type solutions are tremendously valuable for the "blue" institution to socialize.

An example of scenario background development with economic foundations and operational context follows. It flows from a notional example of "BLUE" vs. "RED" Technology Cost Comparisons (This sets context in motion for gaming and thought experimentation. This example highlights concerns as viewed by potential economic disparities and economic offsets, in order to set conditions for war-gaming and learning.)

This comparison highlights the state of BLUE defense technologies with respect to RED defense technologies and highlights technical risk stemming from economic cost impositions. Consider the following unclassified and notional pre-game analysis:

	BLUE Technology, (Approx. Cost*of Access)	***Approx. RED A2AD Economic Advantage****
Comparison	(*e.g. possible U.S. Navy access and maneuverability prompt)*	*(e.g. possible A2AD technology response & cost associated with that response)*
BLUE Carrier Cost vs. RED ASBM Cost	One Nuclear Carrier cost ~$14 Billion	100, DF-21D-like ASBM Missiles, each missile = ~$1M: Total = $100 M (note: ~2 orders of magnitude less in cost)
BLUE DDG Destroyer Cost vs. RED Houbei-like fast patrol boat cost	One DDG ~$2 Billion	5 Houbei (w/ 8 ASCM each) ~$200M (1 order of magnitude less cost)
5th Generation BLUE Fighter vs. latest RED SAM	One BLUE JSF-like aircraft ~$100M+	3 SAM (HQ-9-like.) = ~$3M (2 orders of magnitude less cost)
Quality vs. Quantity *(in terms of Pk comparison (probability analysis only)*	Two expensive SM-like missiles with Pk ~ 0.9 (Pk ~ 0.99 overall)	4 less expensive missiles with Pk~ 0.4 *~ 0.987 overall (e.g. much cheaper technology for same Pk[142])*
AOA to IOC, e.g. design to fielding, [or, analysis of alternatives to time of initial operational capability]	~20-25 years (actual)	~10-13 years (half as long an acquisition cycle)

Table 2. A First-Order Analysis: a Cost Comparison of Blue & Red Technologies
*(*based on notional unclassified analyses. All Pk's are proposed and hypothetical)*

This table shows at least one order of magnitude difference between the costs of "forward BLUE "access capability" vs. foreign RED A2AD technological response." It highlights a severe economic disparity for BLUE, if RED were to pursue this acquisition approach.[143]

The BLUE technology featured is a forward based, offensive capability as compared to a RED "home-game" system (in this case, "home-game" advantage is established via "counter-intervention technologies" – through the acquisition of missiles, swarms of fast patrol boats with anti-ship cruise missiles, and mobile surface-to-air missiles in significant numbers to "saturate" BLUE Naval assets. It does not account for even lower-end anti-access endeavors such as unmanned vehicles or smart mines. It also highlights a possibility that RED acquisitions can be acquired in approximately half the time as compared to the BLUE). If BLUE and RED teams were pitted against one another in a future contest (war-game) and RED advantage played favorably, it might be the basis for the foundational elements of a RED technology or economic strategy.

This cursory analysis highlights strategic technical risk (and potentially tactical risk). Note: this is only a simple, first-order, economic analysis for scenario planning purposes. This "cost-game" shows the potential possibilities of a Chinese economic cost-imposing offset strategy that might play well in an A2AD strategic scenario for China should China pursue that RED pathway.[144] It underscores the importance of high capacity at low cost through A2AD planning. However, taken separately, it does not support any conclusions as to the nature of operational risk from conflict at scale, or in the face of counter-technologies (such as directed energy solutions, electronic warfare or cyber-warfare, at scale). Furthermore, it only offers a supposition to the stakeholders of game-play – in this case "how would one proceed if called into an honest A2AD fight on these terms, with these very plausible technical cost-yield scenarios?

This exercise does not assume triumph, as a contest would have many other factors to consider, including the morale of the men and women fighting, and their proficiency with the technology and ability to execute, for example, using economies of scale. Yet, this type of analysis highlights a different kind of related risk: that of a RED A2AD economic cost-imposing strategy, and its inter-relationship to an over-arching RED A2AD technological perspective. The question remains, "How can BLUE win the contest?" (Or, which side would one rather play in such a contest and why?)

Technological Challenge

An old adage in military strategy is that a military goes to war with the weapons, systems and technologies on-hand. The onset of war is obviously bad timing for a wish list from the front lines[145]. More importantly, this represents an undesirable situation for NAVAIR, NAWCAD and other defense establishments, especially because they invest resources, time and talent to yield desired technological outcomes in advance of war-fighter demands. In this case, inadequate readiness represents churn and change for the institution. It would present great organizational stress and strain (stress over time).

Understanding technological possibilities and probabilities allows for the design of a more robust offsetting technological strategy, should unfavorable terms be presented to the U.S., especially in the form of an actual A2AD scenario. Understanding what is "technologically possible," and more importantly, what is "technologically feasible, probable, advantageous" yields advantage if it can be accepted and actualized just ahead of demand. This is a valuable endeavor. Learning and understanding what may be required to support a robust set of successful future responses in the face of any A2AD strategy may ensure adaptation, if the scenario comes to fruition (plus, credible deterrence).

Technological myths and misperceptions abound with respect to A2AD capabilities. What is the future price of miscalculation? Advanced technological assessments must be conducted for would-be threats using current and near-term capabilities, yet also in connection and comparison to U.S., allied and adversary future technical possibilities.

The critical strategic questions facing NAVAIR, NAWCAD and our defense institutions is "how to answer or trump a formidable technical threat such as that potentially presented by China (or any other A2AD threat) in the near future? Certain technologies "could-should-must" be developed today to be employed against a robust and resilient A2AD strategy in the future. NAVAIR and NAWCAD can support a pathway so that technology can be prototyped, tested, developed and safely fielded in the most expeditious manner.

Seeking to uncover the answer to this challenge is at the heart of the hypothesis that a classified A2AD technology study would be valuable to decision makers at the highest level. A technologically based study of realities today might inform such a more robust technology or engineering pathway for tomorrow, and more importantly adjust the current roadmaps, policies and pathways to achieve it. This study does not purport to deliver this; yet, this study does offer indications of how to

get there. Without clear direction based on future threats, the lack of perspective will cloud the pathways, and diminish potential. Studies that identify A2AD possibilities assist the convergence of economic, technological and military factors. They inform areas of future technology to advance strategies with a "technology-pull" methodology, and with an "order sensitivity" focus, in order to prepare an advantaged position, well ahead of future requirements. The best result from these preparations would be confidence in an appropriate technological U.S. readiness and response, which assures friends and allies, and advances resilient sustainment of forward advantage. This is a pre-requisite for the future of U.S. national security.

Military Challenge

Operational access, maneuver and agility are continuing military concerns. This is especially true for the U.S. Navy when confronting the capacity and capability to act in the face of peer or near-peer competitors with advanced stand-off technologies such as anti-ship ballistic missile systems with ranges of 100's of miles. Denied use of domains in A2AD situations is untenable for U.S. forces and this is particularly true for naval forces which operate with respect to air, sea, space, and cyberspace. In China's case, the term "A2AD" is a U.S. contrivance – it is only translated into PLA writings (versus originating in PLA writings). Chinese official writings use a slightly nuanced version A2AD in their "counter-intervention" perspectives as proposed in PLA writings. These notions are at the heart of military A2AD preparation that threatens U.S. freedom of action, especially for the U.S. Navy. [146]

Understanding the role and position of technology and smart, immediate future technological possibilities, (especially with regard to China[147]) is particularly useful in understanding what can be done militarily. Consulting a larger defense community early and often is optimal to affect a more robust technological strategy design for NAVAIR and NAWCAD. At a minimum, the A2AD situation must be addressed to ensure an acceptable U.S. national security posture, and to reassure friends and allies. Developing a technological roadmap that makes sense today in the face of tomorrow's economies of scale should lead the way to the supported future. The alternative is to deal with a future A2AD engagement with yesterday's technology. This is largely true for technology advancements by the defense laboratories today (and in particular NAWCAD) as they prepare to undertake a transition to a more robotic and autonomous systems based future.

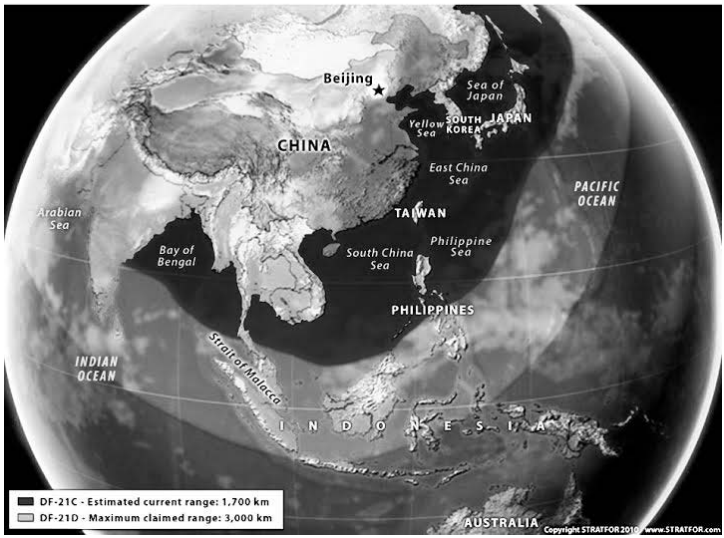

Figure 5. Western Pacific A2AD and the DF-21D: The ASBM "push-back" from Chinese Coasts

A2AD in the Pacific: China, Counter-Intervention Scenarios and Preparations

Modern technologies that have not yet been in full operation (or battle) present a unique challenge for planning calculations that must account for a nation's ability to fight, protect and sustain itself in a regional conflict. This must be considered in defense planning, especially for the U.S. which participates in deep engagement "forward" at locations half-way around the world.

China continues to prepare and account for the United States ability to fight, protect and sustain itself overseas. Planners give weight to considerations of how the U.S. will arrive half-way around the world, maintain itself and fight or protect itself after conflict erupts[148].

Accounting for such endeavors in the face automation and innovation presents a unique challenge for the United States. This is especially true if dealing with an adversary with advanced high-tech capabilities, such as China. China, for example, has achieved a level of true technological sophistication in terms of capability and capacity to execute an A2AD strategy on an operational scale within its region. China's rise can be seen on many technological levels in support of such a counter intervention strategy – mobile missiles with ranges over 1000 miles from

their coastlines, upgraded nuclear submarines and fighter jets that patrol waters far from Chinese shores, air and sub-launched hypersonic cruise missiles in significant reserve, passive coherent localization techniques that potentially trump stealth technologies, and highly integrated air defenses that can shield local action within an inner zone – to name a few149. For this reason the Chinese A2AD scenario remains quite compelling.

The U.S. has not seen this type of "operational competition" since the Soviet Union of the Cold War. Today, concern is on the rise that China (and now Chinese technology) can affect the eastern hemisphere. Chinese achievement of regional influence is also facilitated by the perceptions and misperceptions of other Asia-Pacific nations, including our friends and allies in the region. In the process, American influence may be eroding as challenges to national security continue to increase.

In these scenarios, military forces are not only held at risk by adversaries seeking to do them harm – they are held at risk by the rate of change of technology and the lack of response to such technology. This is a cultural feature of an organization; for example, a military and its industrial complex and their ability to flex to changing circumstances is an attribute of the system. (Born from this notion is the necessity of an offset: novel solutions for the military system to provide both innovation and game-changing possibilities when needed). However, in peacetime or at war, forces are also held at risk by levels of adaptation, whether that adaptation is military agility, institutional change, or an adversary's flexibility.

Should U.S. forces be required to intervene to thwart Chinese regional aggression, the potential outcome is increasingly more uncertain. Asia-Pacific theater planners must take into account that China is now exporting new technologies, (such as the C802/3 surface to surface missile). Other nations are now taking note or even purchasing and adopting China's technological strategy in that regard150. As if these concerns are not enough, in some cases, China maintains critical U.S. supply chains for key U.S. technology sub-components. These chinks in the armor are more readily seen through the lens of cyber-vulnerabilities. The extraction of key technological information from our federal government occurs at an alarming rate, yet from U.S. contractors it is even more pronounced and problematic.[151] For example, even if the government can secure tightly held intellectual property, U.S. companies are estimated to be losing $250 Billion in intellectual property per year.[152] These are all shifting dynamics in a morphing A2AD risk landscape.

An A2AD technology strategy is enabled by advanced and advancing technologies, but also by the system advancing them. China has modernized and advanced their weaponry; including missile and directed energy technologies, which incorporate smart-materials and nano-technologies in their weapons. They have created advanced tactical engineering marvels, from the latest stealth fighters and submarines to mining technologies and unmanned drone systems, which they can field in substantial numbers or in coordinated ways. They have modernized and advanced sensor systems including long-range active and passive radars and other detection capabilities, including satellite systems and cyber-control capabilities. From these sophisticated technologies comes significant operational improvements, such as the coordination between the PLA Army and Navy – including integrated-air-defenses, technological training and logistics upgrades. China now runs sophisticated exercises with regional partners153.

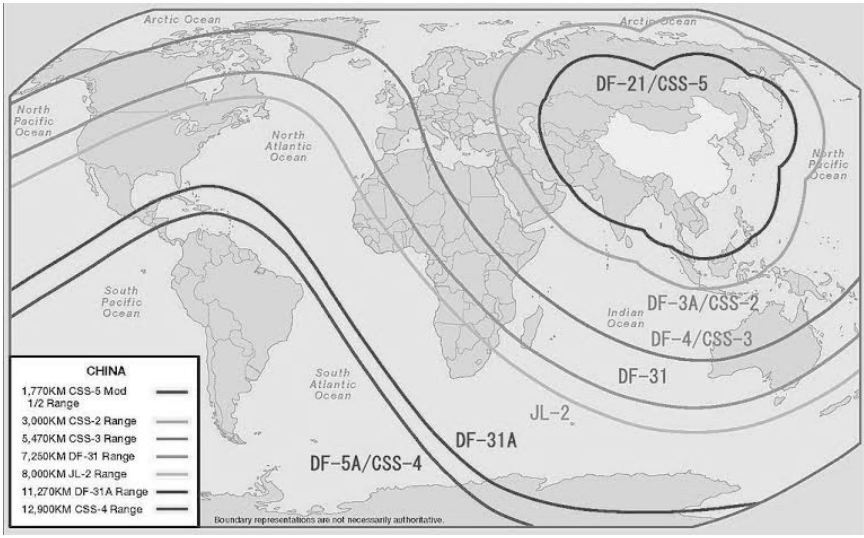

Figure 6. Current Ranges for Missile Technology: CSS and ASCM Missile Coverage from Mainland China

While China's strategic ambitions remain unstated, their technological and tactical level advances in support of a prospective A2AD strategy have been documented and verified by many credible, albeit unclassified sources. Defense force analysts consider that Chinese assets are not only mobile; they can scale across a theater for a wider effect. If America decided to get involved in a western Pacific conflict, it would be to an

increasingly uncertain outcome, primarily because of advanced designs for what PLA planners call "counter intervention technologies." This is not an overstatement of capability – even from an unclassified viewpoint – it is the realization of the potential of technology in combination, and at scale over the region that prevents intrusion and interference against the will of China. It is also the realization of a system designed to support it. The capability of Chinese A2AD technologies combine to create capacity and greatly delay or prevent intervention (which becomes increasingly threatening over time). This underscores diminished U.S. advantage in the Pacific region.

The facts before the world are indisputable – China is inventing, launching, modernizing, acquiring, scaling, practicing, partnering and even taking low-scale tactical actions. These have the effect of influencing area politics. For example, as recently as the first quarter of FY14, China declared no-fly zones over parts of the first island chain (Senkaku Islands) and backed it up with over-flights by modern tactical jet aircraft.154 Some consider this an initial signal of their intent to shape their region. This may be political positioning, yet it may also be an initial display of intent and "shaping" that addresses China's first steps toward declared goals for the "9-dash line." (Chinese view of the first island chain, which China has increasingly laid claims over).

It is also worth noting that in the Annual Report to Congress on China, it was cited that approximately 100 billion barrels of crude exist under the East China Sea and 60 years worth of Chinese consumption can be addressed from crude under the South China Sea.[155] Additionally, Haddick's recently published book "Fire on the Water" also highlights these strategic fuel reserves of gas and oil exist in the contested island areas, and represent 60-80 years of energy for China.[156] In this case, Chinese "counter intervention" strategy may support political strategy to influence international relations. This is all made credible through technological achievements and capabilities, especially when compared with that of the U.S. or allies present but not responding in the region. China is not alone. Other countries are following China's technological lead to influence political ends. Iran is included in those countries, in part due to its nuclear ambitions and the potential to influence the Arabian Gulf.

Critical Questions for NAVAIR and NAWCAD

As scientists and engineers design increased capability for U.S. forces through technological systems via programs of record, organizations

must team, adapt and provide U.S. forces with decreasing operational, platform and equipment risk. This is not a "future calling" – it is critical for our technologists and laboratories to re-orient and respond now – especially if the U.S. is thrust into the challenge of addressing emergent foreign "Anti-Access, Area-Denial" strategies.

A roll-up of current and future strategies can give way to opportunities requiring further review, in order to determine the best way forward for NAVAIR, with particular emphasis for NAWCAD. NAWCAD is a technological leader and one of the most critical technological components of the U.S. national security enterprise. As a pilot study in change management, NAWCAD could then, in turn, be the exemplar and the model for necessary change – and position itself to demonstrate the breadth and depth of human capital and technological adaptation possible. This may align with an economically feasible future where the technologies that undergird it are on a path that drives an effective strategy. This is a pro-active, strategically-guided, technologically agile future, versus a reactive one.

ETC's primary research initiated questions from the outset (to bring up critical factors and trends), to highlight good-thinking with respect to A2AD within the institution, and finally to analyze and conclude with some recommendations. To begin, the initial question to ask was "What should warfare centers like NAWCAD be working on in light of foreign A2AD technical positioning and perspectives?" The focus on current acquisition systems and programs of record yield little time to think through questions like these, which largely remain unanswered for NAVAIR, NAWCAD and many DoD laboratories. Likewise, NAWCAD can use perspectives to shape a new culture that addresses A2AD operational risk with technical endeavors. What technical risk calculations are used in addressing Chinese A2AD positioning?" Questions like these have a future focus and a bent toward design, test and evaluation. For example, "Are NAVAIR and NAWCAD *conducting and leading* appropriate technical, scientific and engineering activities to support a well-tested Department of Defense A2AD response if and when forces are called to project and sustain power overseas in the future (e.g. nearer to Chinese coastlines, for example, which are obviously half-way around the world from the U.S.)? Advancing the answers to these questions can position U.S. forces with a technological advantage, especially if called to seize the initiative in a region where a large-scale "counter- intervention" strategies are being implemented (across the scale of an entire theater such as in the Asia-Pacific). How are these questions being addressed at NAVAIR, NAWCAD and other federal

laboratories, what metrics are used, and how do they roll-up in a combined, technically-savvy, coordinated plan of action for DoD? That is yet to be determined.

Special consideration must also be given to domain coordination from air, sea, space, cyber and sub-surface realms. These are largely technical endeavors, or at least initiate from a technical perspective. Understanding that intervention initiatives will likely be secured initially using the U.S. Navy in a forward concept such as Air-Sea Battle, what specific technological endeavors "could-should-and-must" a Naval Warfare Center such as NAWCAD prepare for as a critical component of a U.S. technological response for the entire air-sea domain?157

Opportunities for Collaboration

NAWCAD future positioning and technology roadmaps are needed to support Naval aviation in order to obtain advantage in an uncertain A2AD future (assuming U.S. Naval aviation remains a cornerstone of U.S. Navy power projection). NAWCAD requires a more in-depth discussion of the technologies that support and challenge A2AD positions for the future, (specifically naval aviation-related future positions). From this evaluation one can determine if critical adjustments to the technology test and evaluation portfolio need to be made. That is one method of addressing the risk. However, if the current NAWCAD strategic preparations are inadequate, there must be a strategy for change management to ensure successful fleet support. This will require a cultural shift to include institutional perspectives in designs for viable solutions for the enterprise.

The potential of high-impact foreign technologies to bypass the acquisition programs of today and tomorrow would be essential to not only know – but to ascertain right now – in order for decision makers to make key adjustments in time to be reflected in a future Naval capabilities portfolio that delivers the required capacity to a forward operational commander. Leadership must be connected to those technical leaders subordinate to them to begin making in-roads to this determination. The potential to develop a rapidly delivered future technological portfolio may be an economic-cost imposing strategy in itself that might deter would-be adversaries from devising adequate short term counter-intervention measures. These types of considerations for the future may present extraordinary technological risk to ones adversary, and serve to counter, or even offset an adversary's A2AD strategy. Additionally, these process considerations may create strategic

surprise and continuous deterrence. At a minimum, the goal is to achieve a robust and resilient technology portfolio (supply) slightly ahead of warfighting (demand). At best, the goal is to achieve specialized technology or operational offsets that are both affordable and can deter the threat of war from would-be adversaries.158 This will likely occur only through effective collaboration within the enterprise.

More recently, a number of very productive games and discussions have led NAVAIR, through NAWCAD, to assist in technological strategy development, especially through the use of games and simulations. For example, a "2030 Strategic MMOWGLI" (Massive Multiplayer Online War Game Leveraging the Internet) was conducted at NAWCAD to gain insights and crowd-source information that could affect a deeper NAVAIR strategy. These discussions included ways and means to aid the development of Navy and DoD war-fighting positions relative to Anti-Access Area-Denial thinking.

Included in these discussion were initial attempts to understand the fundamental nature of rapidly changing technological fields such as nano-technology and material science, directed energy and energetics, autonomous systems and autonomous control systems, missile design, communications technology and network science. Coordinated "play" with the concepts yielded insights that are not obtainable by leadership alone.

Subsequent Chapters reflect similar viewpoints as were assembled from the MMOWGLI, and they begin to address the A2AD situation. Perceptions of A2AD and the institution follow, realizing addressing the situation can occur from a warfighting and an institutional perspective simultaneously. Also, recommendations are offered for ways forward for NAWCAD so they may continue to reconcile future viewpoints, data and analyses while considering future decision environments of their own.

Finally, this study is offered with references to the current A2AD body of work and publications. Over 80 contemporary and high-level open-source publications were consulted on these topics. These references were examined and organized for A2AD interpretation for the NAVAIR and NAWCAD organizations. They are offered for further review.

In summary, *the interplay of possibilities is clearer through the lens of A2AD scenario game play with multiple players. It is clear from the study team's examination of institutional perspectives (which is reflected in Chapter 5 of this study) that many leaders have personally grappled with these concepts, yet very few have gamed the concepts in larger*

groups. The question for the institution is whether these leaders should also be invited by design, to devise and test concepts as a team of institutional and enterprise leaders.

The U.S. Navy stands forward and ready with institutional readiness in support. ETC conducted primary interviews to add to the collective institutional knowledge on the subject of A2AD. The uncovering of many new ideas through high level interviews of national security leaders is also included in this study. Chapter 5 presents primary research from interviews of 3-4 star flag leadership, and interviews of NAVAIR leaders including program managers. It also includes primary research from perspectives of Pacific planners as well as thought leaders from institutions such as War Colleges and post-graduate schools. This study attempts to shed new light on the A2AD subject to date, and is certainly offered to advance the A2AD conversation. As one will witness, there are more questions than answers with respect to A2AD. Yet that does not mean that robust and resilient strategies cannot be designed. A good assessment at this stage highlights both question and speculative answers. Yet to enter the arguments, additional background is needed. Understanding the viewpoints of institutional leaders on A2AD is vital to NAWCAD readiness, decision making and change management solutions.

A call for military intervention in the face of anti-intervention strategies and technological responses is clearly one of the most risky near-future scenarios for U.S. forces. Many believe the likelihood of possible conflict in Asia-Pacific is increasing. If the U.S. military is required to respond to crises in the region, and intervention escalates into a large-scale regional war, outcomes are assessed as uncertain at best. To be relevant, the U.S. must coordinate their military responses with technological A2AD support structure responses.

To gain understanding of the technical risk through exploration and gaming of new concepts is to uncover new terms of likelihood and severity of outcomes: it is to devise a viable technological possibility set. An overarching technical A2AD assessment can be more aptly formed from the high-ground associated with the patterns and correlations extracted from a series of A2AD scenarios and war-games for the institution. However, that assessment would remain insufficient if a change management implementation strategy does not follow for the naval enterprise. For example, a technical plan that highlights responsibilities for NAWCAD's technologic mandate for rapid change in support of unified plans.

Time is of the essence when considering the specific technical elements and risks associated with A2AD strategies, especially in light of "shaping events" being witnessed in the Asia-Pacific region. The necessity for a coordinated plan has been proclaimed by many in the national security sector. Chapter 5 will examine some institutional leaders viewpoints in that same light.

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[139] Peter Schwarz, "The Art of the Long-View", 1996, Bantam Books. P 37, 108. Peter Schwarz defines the long view guided by scenario planning: "Scenario creation is not a reductionist process: it is an art, as is story-telling. It is about how you perceive [various] elements in various situations. The end result is not an accurate picture of tomorrow – but better decisions about the future." "Scenarios deal with two worlds: the world of facts, and the world of perceptions. They explore for facts but aim at perceptions inside the heads of decision makers. Their purpose is to gather and transform information of strategic significance into fresh perceptions. It can lead to strategic insights beyond the mind's previous reach." "The scenario method systematically raises people's understanding of their environment and each other." The caution: "A point should be made to consider a wide array of perspectives – from the outside – a purely internal conversation, or worse, an internal monologue, will rarely be able to achieve break-through thinking."

[140] Tangredi, 2013

[141] JOAC 2012

[142] Drennan, Jimmy. ""Strength in Numbers: The Remarkable Potential of (Really) Small Combatants" Naval War College Review, Vol. 67, No. 1 (Winter 2014).

[143] Gady-Franz Stephan. "What can the Middle Ages Teach US about US Naval Strategy." The Diplomat, 12 March 2015. Web 15 March 2015.

[144] Hendrix, Henry. "At What Cost a Carrier?" Center for a New American Security, March 2013. Web 15 March, 2015. *Note: Cost Analyses like these can be used to supply a reasonably analogous, order of magnitude assessment – or " economic comparison based on PPP" – for the purposes of refined war-game construction.*

[145] A military cannot use the weapon systems or technologies it desires that do not exist whether those systems or technologies have not yet been invented or manufactured, or whether those systems and technologies were previously invented, but are no longer maintained in the inventory)

[146] United States Congressional Research Service, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress* – 2013.

[147]Chinese Strategy and Modernization Efforts include A2AD strategic efforts to gain and maintain operational advantages. Air Sea Battle – Jan Van Toll – 2010.

[148] Dutton, Erickson, Martinson, "Chinas Near Seas Combat Capabilities," 2014, U.S. Naval War College Press. Also Scobell, Lai, Kamphausen, "Chinese Lessons from Other People's Wars", Forward, Ch 1-5. Note: *China has clearly studied the Air War in Kosovo, the Falkland Island conflict, the missile wars of Iran-Iraq, and both Gulf Wars to discern U.S. patterns, and more importantly, counter-measures that appeared to work or failed, including the reasons why.*

[149] *Defense Science Board: Technology and Innovation Enablers for Superiority in 2030*. Washington, DC, 2013, Executive Summary

[150] Dempsey, Martin E. (General, USA). *Joint Operational Access Concept*. Executive Summary.

[151] Bucci, Rosenzweig and Inserra, "Seven Steps to U.S. Security, Prosperity and Freedom in Cyberspace" April 2013, Heritage Foundation, retrieved from http://www.heritage.org/research/reports/2013/04/a-congressional-guide-seven-steps-to-us-security-prosperity-and-freedom-in-cyberspace

[152] Ibid.

[153] *Defense Science Board: Technology and Innovation Enablers for Superiority in 2030*. Washington, DC, 2013, Executive Summary

[154] Wall Street Journal, "Concern Mounts in China's Air Defense Zone-Beijing Sends Fighter Jets," Nov. 28, 2013, http://online.wsj.com/news/articles/SB10001424052702304017204579226031095207724

[155] Annual Report to Congress: Military Security and PRC, 2013, p. 21.

[156] Haddick, Robert, "Fire on the Water" September 14, 2014, Naval Institute Press.

[157] Tol, J. v., Gunzinger, M. A., Krepinevich, A. F., Thomas, J., "*AirSea battle: A point-of-departure operational concept*." Center for Strategic and Budgetary Assessments. 2010. Summary.

[158] Specialized Technology offsets can be made manifest if the U.S. possessed overwhelmingly superior technological capabilities or capacities - so great that an adversary could not expect to overcome them at reasonable costs or in time for the conflict. Such an offset must be a credible deterrent in the mind of a would be adversary and comes with many indeterminate variables. Measuring a flexible deterrent option is tricky and is not offered here as a foregone conclusion.

Chapter 5

Stakeholder Interviews: A2AD Perceptions, ETC Analyses

Background:

ETC conducted primary, first-hand research through targeted interviews of key stakeholders across DoD institutions on the topic of A2AD and its impact on warfighting, naval aviation and the naval enterprise. The stakeholders came from four distinct categories:

Venerable Thought Leaders: knowledgeable and experienced national security professionals, including Naval Postgraduate School graduates, Naval War College graduates and professors, Strategic Studies Group members, and other DoD think tank leaders. The background for the interviews included literature reviews and phone conversations with professionals from NPS, NWC, SSG, NDU, NWDC, ONR, DARPA, CSIS, CSBA, CNAS, Carnegie Endowment, Center for New American Studies and JCS research groups with reviews of many publications and articles.

Navy Strategic Leaders: SES-level officials, Laboratory and former Laboratory directors, former major Program Directors, present and former Technical Directors, Pentagon officials, and 3- and 4-star Flag officers. Background preparations included literature reviews and prior public statements and interviews, including those from videotaped panels, keynote speeches and public press releases.

NAVAIR/Program Leaders: major Program Managers, PEO's, institutional veterans of the warfare centers and warfare center leadership, including Flag officers. Background preparations included literature and website reviews, patent portfolio reviews, program understanding and review, naval aviation vision and strategy statements, and naval aviation-specific research.

Pacific Fleet stakeholders: planners and fleet leaders who have served or currently serve in the Pacific theater and who face the operational prospect of A2AD daily. Background preparations include reviews of unclassified writings and plans, and the positions of Combatant Commanders and published PACOM statements.

Disclaimer: This chapter is an abstract and reflection on the comments and insights of twenty high level personnel from the categories listed above. While the twenty interviews are very revealing and thought-provoking, they represent a small number of professionals within the Navy and the DoD. A sample of this size is not statistically significant, and the results do not purport to be conclusive or to represent an official position. Neither do they advance any stakeholder's particular interests. They are not intended to reflect the official views of the DoD, U.S. Navy, U.S. military, or U.S. government more broadly.

The interviews conducted are the formulations of the individual interviewees' thoughts, opinions, and professional perspectives alone, and they are characteristically linked to their personal biases and heuristics. While those interviewed are among the smartest and wisest of our institution – twenty to thirty year veterans in their fields – it is recognized that no one individual knows anything larger than has been compiled in any other professional way. Yet, this set is twenty more interviews than has been written and published on the subject of the A2AD scenario, as presented in any one current publication available today. It adds flavor to understand the body of perspectives from within DoD organizations in juxtaposition to the body knowledge of the subject of A2AD. The goal was to offer the insights of this elite group of professional stakeholders as a representation of the possibilities and opportunities for knowledge capture and change management. If efforts like these can be advanced, developed and scaled across the institution there will be benefit from the "wisdom of our own crowds".

"Alone we may have few points of true understanding, yet together we reach enlightenment."

A note on classification: The background and content of the interviews were designed at the unclassified level, and have purposefully been left unclassified. Given the specificity of the subject and content however, EACH interviewee independently emphasized the importance of a CLASSIFIED follow-on to the present study. The feeling of each

interviewer on the study team is that a classified study is warranted and would be even more useful in conjunction with this initial study.

Goals: The goals of the interviews were threefold:

(1) To design a sequence of challenging, thought-provoking, and useful questions to advance the conversation among readers and stakeholders. This goal was to not only to serve the interview process but to prompt others to delve more deeply into the A2AD challenge. The secondary objective is to stimulate dialogue and inquiry into the A2AD problem and its potential solutions on all relevant levels – including basic and applied scientific levels. Care was spent to devise questions that penetrated to the heart of the matter, minimizing confirmation bias and eliciting provocative, unscripted and reflective answers. The questions scaled deductively down from broad national and DoD perspectives to challenges specific to the US Navy and Naval Aviation, and horizontally to the challenges that the A2AD problem presents to the naval enterprise and NAWCAD. The interview questions can be found in the survey section of this chapter and are open to further input and refinement. As a good engineer will attest, when the problem is scoped correctly, the resulting solutions will be more approachable, applicable, and formidable.

(2) To advance awareness and unleash knowledge of the A2AD challenge within DoD, with the aim of opening opportunities and igniting powerful convergences on the topic. This goal is to spark challenging discussions. Interviewing influential career professionals clarifies concerns and the potential perils and pitfalls associated with the problem. It establishes conditions for the emergence of new concepts. Just as important, it harnesses the brain power of the Defense Department's ecosystems, as viewed from its wisest individuals, who are in a position to influence the engagement of others. This is a worthwhile goal in itself. These interviews served to cultivate the "wisdom of the crowd" and the potential to learn, grow and interact with stakeholders in a joint enterprise. Solutions may ultimately result from the buy-in and collaboration of those within the institution. The institution is far better off when "good ideas

have no rank" and they can be brought forth for institutional learning.

(3) To sample and discern patterns and correlations in the state of thinking within the DoD and the Navy, as well as to discern divergence or dissension, all with the aim of cultivating the growth of NAWCAD as a "learning organization." As with the goals above, the benefits are twofold: (a) to grasp the bases and outcomes of institutional knowledge, and (b) to gauge the intellectual health of the institution. Only then can leaders and policy-makers better advance, change, and improve thinking about challenges like A2AD. This is basic to a program of "knowledge management" – and integral to the plot for more effective courses of policy execution. In light of this avenue of discovery, several questions for the institution come to mind that could not be fully anticipated in this short study:

- Are folks collaborating?
- Are folks communicating?
- Do they know something about solutions (technical or otherwise) that their leaders do not?
- Can knowledge be exchanged in a healthy way?
- Is knowledge getting to the places and people that need it the most? Or are professionals concerned or 180 degrees opposed to current policy, thinking or direction?
- Is anyone asking? If so do their positions or interests correlate? If so, what does that indicate?
- Moreover, is the organization fostering an inquisitive and informed discipleship or do senior level officials misrepresent the actual morale or interests of the group?
- How do leaders' survey? What metrics do they use to judge responses?
- What is the relationship of ideas of professionals on professional topics to the very ideals of the institution itself, and to the execution of day to day actions?

This line of thoughtful pursuit is one that the best learning organizations embrace in their culture. Organizations that learn from the professionals which comprise it gain advantage from the collaborations. When there is time to ask and answer questions, it can be a healthy

pursuit for an organization, and although the answers may be disruptive, there will be "grains of truth" in the responses. Research indicates that when this is a known quantity in groups, there are usually good communications, and self-actualizing individuals getting things done. Little in the interviews themselves suggest that there are meaningful answers to these questions on the basis of the material gathered, however, when further surveys and interviews can be designed at scale to solicit institutional knowledge and feedback, approaches to those answers can begin to be made and aggregated.

When institutional perspectives are not in synchronization with an organization's goals, often "culture" takes the blame. Hopefully "pacing" surveys like these can bridge that gap and inspire organizations to at least understand the gap. These surveys were meant to stimulate interaction in order that decision makers could begin to sense the thought-flows on A2AD and be in tune to the characteristics of the culture of inventiveness that exists within the institution. To understand perspectives and culture, and what is in line or what is 180 degrees out, is to be deliberate about eliciting novel solutions, and the idea of seeking to involve professionals in those novel solutions. Surveys and interviews advance the institution toward becoming a learning organization, and advance attraction to the organization by other people from other associations who understand that the institution cares about what its experts think. When those in the institution know someone is really listening, and truly cares about their responses by way of feedback, then they will engage on many different levels. The authors feel these interviews not only helped in aggregating comments, but also sent a message by way of interaction - a signal to those interviewed that their opinion matters. This is a healthy loop, and a goal achieved throughout the interview process.

Survey:

The A2AD Study Team interviewed twenty knowledgeable stakeholders and strategic thinkers. To solicit honest feedback, anonymity was a precondition of the interviews, as was a commitment to non-attribution, as well as to de-identify the data for independent analyses.

NAWC A2AD Study Questions

First questions, designed to scale from broad DoD challenges to U.S. Navy Challenges and Naval Aviation challenges, with regard to A2AD:

- What do you see as the biggest challenges facing DoD, and the U.S. Navy? [… today and in the future ~2030]?

- What future technological threats do you envision represent the greatest challenges for the U.S. Navy and naval aviation?
- What would you see as the biggest opportunities for the U.S. Navy and naval aviation, specifically in addressing high-end challenges such as A2AD?

Assumptions:

- The Navy is facing problems
- There are threats to the Navy and Naval Aviation, and many are technological
- Participants know what A2AD is and that it represents a challenge

Second set of questions (follow-up questions):

- Is the aircraft carrier vulnerable in the future?
- Is the Carrier Strike Group (unit of issue to the joint or combatant commander) a strategic liability in the future?
- What should the nation do to deter and/or defeat A2AD concepts for major combat operations?
- Where should R&D be invested to address future evolving A2AD threats?
- How can the U.S. Navy better accelerate counter-A2AD technologies?
- What technology solutions are there? (Can technology help? How can technology help?)
- What naval aviation technologies and capabilities (e.g. platforms to Warfare Centers) should be developed and accelerated?
- How can we best sustain the long term relevance of the CV and its Air-wing?
- How might service roles and missions change in future A2AD environments?
- On A2AD, we are spending X (trend) and adversaries are spending Y (trend)…
- Based on X and Y, can we maintain sufficient access or do we need a new strategy? (Do we have to continue with power projection as we do today?)
- Are there other effective ways to advance?
- What are your perspectives on Naval technologies with respect to A2AD challenges?

- What are your perspectives on Naval Aviation with respect to potential A2AD challenges, and what does that mean to you?
- Are A2AD threats real or perceived? Why? (soliciting engagement on the "likelihood" discussion)
- How important is Naval Aviation's role anticipated to be in re joint, allied or combined efforts in the future? Why? (soliciting engagement on the "relevance" question)

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***Stakeholder reflections and perspectives*:**
Considering the survey questions and an A2AD scenario for planning purposes, data from the participants' perspectives were gathered. The data is provided in Appendix 1 of this book (please see APPENDIX 1).

Summary of Analyses:

The following research observations are derived from correlations and patterns from the majority of the interviews. They represent the most important common themes:

- A consensus of the interviewees held that the A2AD contest will be a layered, complex battle on a scale and tempo that U.S. Naval Aviation has not witnessed in decades, if ever. Naval assets attached to platforms – particularly aircraft carrier-borne air wings and stand-off missile systems – will wage and bear the brunt of the battle.
- All interviewees voiced a strong appreciation of the uniquely maritime character of the A2AD challenge (from the initial battle for seaborne access to sea-basing, sustainment and execution in theater – with mission sets from ISR, logistics, protection, cross-domain fires, and establishment/maintenance of freedom to maneuver or act).
- Interviewees agreed that the current approach to the challenge includes four discrete contests [initially and throughout an A2AD contest]: information acquisition and verification, in-theater staging and basing (including sea-base establishment and base-defense), undersea advantage, and precision strike.
- Interviewees recognized that Naval Aviation platforms and systems are primary and obvious targets. *ALL interviewees expressed understanding and clear focus of the limitations and*

vulnerability of U.S. aircraft carriers and carrier battle groups. Interviewees considered this obvious, and that a loss of carriers in any peer-derived A2AD contest was not only likely, but a foregone conclusion.

- Interviewees showed a keen appreciation of novel elements of the A2AD challenge, most notably offensive and defensive cyber capabilities and space-based competition (C4ISR and anti-satellite), and underscored that units and assets will be cut off, misinformed, and likely forced to operate at local commander discretion in the face of enemy deception and jamming. The convergence between cyber and electronic warfare (EW) was also highlighted as an area of concern and opportunity.
- Geopolitical alliances will be a vital component of any effective 'solution' to the A2AD problem (bearing in mind that if Allies present major complications to effective and efficient planning, a lack of allies presents a condition that is far worse). There was strong recognition that our alliance commitments could draw the U.S. into a western Pacific A2AD conflict, but that a lack of allies limits U.S. basing and maneuver capabilities.
- Some interviewees discussed **a range of A2AD-relevant technologies**: ***next-generation carrier-based unmanned systems; high-endurance platforms; next-generation surface warfare capabilities (like Railgun and stand-off missile systems); novel C2 and software systems; network analyses tools; and in particular, directed energy weaponry; and advanced sub-surface systems, such as submarine-launched/recovered aviation assets and interdiction systems.***
- All acknowledged that technology's potential must be balanced against strategic clarity: if undue dependence on technological dominance is the default response to the A2AD challenge, then the U.S. Navy faces higher volatility of potential outcome, including potential defeat in the event that the technological edge is lost. Many aspects of the technological state-of-the-art in Naval Aviation, however expensive, may already be vulnerable to relatively cheap countermeasures.
- Interviewees expressed concern about losing one or more carriers and the majority of manned aviation assets in a *short period of time* in an A2AD conflict at scale. Many expressed the idea of the *"tempo" of conflict* being of a different character than has ever been witnessed in war at this scale – for example,

decision making must occur within seconds and human reaction times may be categorically inadequate for the pace of adversary unmanned systems or missile systems.

- Interviewees agreed that DoD's "acquisition warrior" focus has privileged the bureaucratic mechanics of acquisition over discovery from hard science and engineering, or technical discovery and solutions. Many discussed a "Program management trumps technology development" theme. A budget is an indication of priorities. The majority of those interviewed discussed the notion that the processes of technology development and engineering problem-solving have been driven from the Warfare Centers for the want of efficient acquisition organizations.
- Interviewees voiced acute concerns for high life cycle support costs and increasing weapons systems acquisition costs. They agreed that modeling and simulation (M&S) can help reduce acquisition costs, safe iterations and system development time, as well as help designers and developers to deal with complexity, interoperability, and "system of system" integration challenges.

Conclusions:

Taken together, the interviews performed on behalf of the present study make clear that the A2AD problem is THE most important scenario facing NAWCAD and the Navy as a whole. The strategy of "assured access" and "freedom of maneuver" for naval forces in the conventional 21st century maritime context poses grave challenges for the U.S. Navy, particularly those organizations within it tasked with technologically preparing and supporting the U.S. access battle against determined A2AD defenses.

Categorical and superlative terms like "dominance" have blinded the nation's political and naval leadership to the importance of novel strategies and disruption of adversary strategies. Historical analysis underscores that true access in strategic terms, "costs" a large multiple more than disruption and denial strategies whose aim is counter-intervention. The capacity to address access and denial strategies may be shrinking and U.S. preparedness may not serve to support the nation's network of allies and partners in the western Pacific region, as has long been assumed. Put differently, the benefits (in strategic terms) that the nation can achieve its ultimate goals by revising our understanding of the A2AD problem, are a good place to begin. Moreover, one cannot overlook the idea that in a potential A2AD contest, strikes on the

Chinese mainland or other key strategic assets come with a very high political and escalatory nature, as they could incite a nuclear position in the ensuing conflict. During the interviews, it was proposed by several that given the continually high costs of access, it seems prudent to reconsider instead the possibility, however unsavory, of an attrition battle that draws on transoceanic U.S. capabilities and deprives the enemy of access to markets and commodities and forces an adversary nation "back onto itself". Such a prospect cuts hard against not only the prevailing strategic priority of access, but the prevailing culture of naval aviation as an organization that hearkens in its concept and structure to the Battle of Leyte Gulf in 1944-45, and which continues to center itself around an unwritten design paradigm for the "decisive battle." Concepts and discussions such as these may not reach universal agreement, however they serve the purpose of connecting the thoughtful opinions and understanding of the institution to the novel solutions unto which it is working and building upon. These discussions serve to inspire a culture of learning and exchange of ideas so that the institution can grow, and so that leadership can harvest the true brainpower of the men and women who also serve in the enterprise – such as NAWCAD. Solutions to complex problems can come from within, through collaboration on topics like A2AD.

Rapid or radical change through dialogue alone, particularly within a long-standing naval institution or enterprise such as a warfare center may not change or catalyze the organization itself. Additionally, in the Navy, high-level analysis has long focused on devising decision-quality metrics for the CNO and OPNAV, the character of whose decisions militate against thinking speculatively against so much future uncertainty. If history is any guide, senior service leaders will always weigh risks by questioning levels of risk and potential reward, yet will probably prove reluctant to alter institutional habits and priorities until the Navy is dealt a terrible defeat. However unfortunate, this is a sobering reflection and impetus for both knowledge management and change management. Senior service leaders view the world and their operations through many risk metrics, and assess risk of warfare at tactical and even strategic scales, while also attempting to factor institutional risk. In this regard, the long view must be considered with the near term. For example, reflecting on sacrificing the far term for near term decision making challenges can affect the institutions health and relevancy over time. It was reflected in the interviews that leaders, as members of the institution itself, will question every decision for bold innovation – technological, organizational, or conceptual – as a trade-off that would cost the Navy's

established stakeholders dearly in the near term. Often in the process, viable alternative thinking and future planning is dismissed.

In most regards, those interviewed perceived that leadership has been made well aware that the most pressing strategic requirement of a real-world, A2AD conflict with China or Iran, is for a mixed set of deterrent options comprised of gradual escalatory alternatives, all leaning toward less-than-decisive outcomes against opponents optimized for anti-access warfare. In general, skepticism was reflected through the interviews that just such a strategic requirement or a viable set of mixed deterrent A2AD options could be generated at present by the power projection capacity of U.S. naval aviation alone. In short, very logical questions were posed that challenge the future capacity of the carrier and its air wings. Instead, the more prevalent view was that naval aviation and NAVAIR leadership continues to focus relentlessly on winning decisive battles of the last wars for carrier aviation, a particularly difficult prospect in light of trends in technology and operational potential of A2AD at scale. Since 1991, the U.S. Navy – no less than the other services, to be sure – has labored under the concept that technology and brilliant maneuver would produce rapid, decisive victories in all manner of scenarios. While this may be true in the past, A2AD presents a different and more challenging character of battle fought at new scales, in new domains at altogether different tempos. Potential opponents have studied U.S. capabilities and intentions carefully, and deduced the warfighting spectrum to devise effective regimes of denial and disruption. The result is that the U.S. Navy is rapidly approaching an inflection point involving the impact of technology on its own warfighting possibilities and limits with respect to those of its potential adversaries. It was believed categorically throughout the interviews that there exists too great a focus on ships, particularly aircraft carriers, in the U.S. Navy, when the approach should be on addressing the declining utility of manned tactical aircraft, and the way munitions are delivered to targets, including the need for deriving fresh alternatives to each (e.g. tactical and operational delivery using missile systems, hypersonics, directed energy systems, fleets of unmanned systems, etc.)

Judging by the tone of the interviews, it was also obvious that the benign operating environment of the past two decades has lulled service leadership and masked the relevance of large, expensive, major combat systems, like carriers and even manned carrier aircraft. Several stakeholders reflected that it certainly has not helped that the institution of naval aviation has not been meaningfully tested in four decades – not even in 1990-91 Gulf conflict, when it faced no significant threat from

Iraqi SAMs or aircraft. In a dense A2AD environment, the challenges and difficulties of operating a carrier effectively multiply and scale radically. Crucial here is not the number of sorties that the carrier can pump, but the difficulty involved in doing so as the carrier is also dodging, hiding, sprinting, deciphering reality (through ISR and mixed intelligence sources), which challenges the notion of its utility in such circumstances. The carrier as a high value unit is increasing in value, and suffers from vulnerabilities in nearly every domain (cyber, air, space, surface, subsurface, etc.). Defending the utility of manned aviation in a structural sense may soon consume the greater part of the Navy's operational energy. If the cost of defending a platform is greater than its offensive value – measured variously – then the platform is considered senile, as many interviewees have argued that the carrier with manned tactical aviation has become. The majority of *meaningful* improvements in tactical aviation and the systems that enable it over the past few decades have been largely defensive and incremental in nature, as similarly compared to the gradual improvements in offensive utility. It was clearly reflected to the interviewers that in an A2AD context, this will be exploited by an adversary.

In this connection, it behooves the Navy's leadership to weigh the increasing value of warheads delivered by missiles from great distances, as there are fewer and fewer places where manned aviation can go at acceptable risk from a variety of competent systems. Missiles – deployed to some extent from drones and UCAVs – are not merely promising but inevitable substitutes, particularly when the exorbitant cost of the F-35 has led to a production rate of two aircraft per year and consumed resources perhaps better expended on developing alternative methods of munitions delivery.

Several novel solutions were conjured up and presented through the viewpoints exchanged in the interviews that offer additional value from this study. An idea that the great value of Naval Aviation – which may prove historically ironic, given naval aviation's institutional roots in the interwar period – lies in the ability to derive situational understanding to direct fires, as opposed to also delivering them. Given the nature of the risk in A2AD scenarios to manned aircraft, the Navy's entire ISR complex could be built around this past-as-prologue-type concept, particularly if the Navy can also field an effective rail gun system in the coming generation. For example, given that approximately two-thirds of the current weight of a conventional shell or missile is oxidant/ propellant, the railgun round needs no oxidant or propellant, and in that way promises to enhance radically the delivery of firepower. The idea of

the railgun, coupled with the idea that inert rounds can be easily stored or potentially fabricated underway, leads to novel U.S. Navy solutions addressing firepower. Additionally, other weapon systems, such as directed energy systems (lasers or high-powered microwave systems), convert fuel into shots. In so doing, they change the operational nature of engagement for naval aviation assets. For example, in-flight refueling also becomes in-flight re-armament and has meaning for the change in character of air warfare or air defense (anti, or counter-air warfare). Considering weight issues with human-factors systems of manned aircraft – an unmanned aircraft can carry more fuel and thereby more rounds due to less weight, or adapt to greater distances with fewer shots (until refueling, which is again, rearming). In this operational concept scheme, target acquisition will depend heavily on naval aviation assets operating in highly contested environments and at great distance from the point of delivery. Unmanned systems that can defend themselves and target using directed energy, while directing fires, such as from railguns, can add naval capacity in an A2AD situation.

Essential in this connection are long-range, high-altitude, high-endurance ISR systems with the capacity to penetrate oppositional airspace, create “long-haul” links, and scout for weapons delivered by stand-off assets. For example, a carrier air wing comprised of E-2Ds for C2 of forward surface-to-air artillery along with a handful of F-35s and F/A-18s for marginal missions requiring manned assets might only supplement the huge numbers of large and small man-controlled and fully autonomous unmanned vehicles, optimized individually for a spread of mission sets. Unmanned assets may not necessarily be solely assets launched from aircraft carriers. In this scheme, the fleet would provide the firepower and the carrier would provide knowledge management via distributed C2 through its airborne assets. This also recognizes the likelihood that the adversary best able to seize and hold onto information dominance in the opening stages of the access battle will gain advantage as the battle opens, which can influence the outcome. This is understood presently as an optimal convergence of electronic warfare and cyber warfare in a complex electro-magnetic environment. Additionally, the exploration of the A2AD scenarios with stakeholders revealed insights. For example, it is universally understood that the Chinese have worked to devise ways of knocking out U.S. ISR capabilities, so the capacity to reconstitute an airborne ISR regime and populate the battlespace over and over again amongst adversary jamming, targeting and deception will be essential. A2AD will therefore present adaptive versus static warfighting environments. In these

scenarios, the carrier and its swarms of unmanned vehicles could reprise their role of the 1930s and become the eyes (and the distributed brain) of the fleet.

Moreover and importantly, it is conversations such as these that the institution could be examining and using effectively to inspire innovations from the warfare centers themselves. This is essential for leadership to grasp, if an effective change management strategy is to be both devised and implemented for the future.

One of the current and principle ideas on the chief virtue of naval aviation is the ability to generate high numbers of sorties of manned aircraft. It has been reflected that this ideal alone has come under question when in the light of an A2AD scenario, where it is of scant value (if any value at all) in the face of modern, layered, mobile, anti-access technologies and systems. In fact, the fragility of the carrier system has been called out – the very question of carrier vulnerability is stressed to its maximum in an A2AD scenario and was reflected in the comments from the interviews. In this sense, it is recognized by the majority of those interviewed that it is a platform at serious risk of "mission kill" (say from one leaker in a hundred of anti-access missile systems at an adversary's disposal). The idea that an adversary could seriously delay U.S. power projection by "bottling up the hornets in the hive," may be of even greater value to an adversary than actually sinking a carrier and dealing with the political ramifications from disturbed Americans. The nature and tempo of this A2AD exchange may be that even delays to launch or recovery in a fragile system could mean an adversary achieves counter-intervention for the period of time they desire (note: A2AD is a U.S. construct, and adversaries often write of counter-intervention objectives, which is a slightly different philosophy).

Acquisition solutions and the hidden power of American industry are often touted as an antidote of sorts, but acquisition solutions alone cannot win the battle against a determined A2AD opponent. Consistent with the Navy's long-standing business model of major program development, however, many solutions seem to be acquisition-based and breathtakingly costly, which was another theme echoed in the interviews. Institutional stakeholders and the leadership of the overall Navy and aviation communities have been made aware of the changing operational environment, but continue to strive for 'sustaining innovation,' to borrow a concept from Clayton Christensen. There is an unknown but visceral cost of focusing on the immediate, evolutionary or incremental goal, at the expense of other long-term challenges or revolutionary pathways. This notion is perceived by stakeholders to be gradually eroding capacity

for operational effectiveness. It is also believed that some, like the Naval Air Warfare Center Weapons Division (China Lake), have worked to peer beyond the Future Years Defense Program (FYDP). But most continue to be bound by Program Objectives Memoranda (POM), and limp along with planning horizons anchored in this or the next government fiscal year.

Like many actors – corporate and governmental alike – in the contemporary technological marketplace, today's Navy laboratories and warfare centers struggle with the challenge of designing, building, and maintaining increasingly complex systems, especially software systems. The technical development efforts of previous generations – those which led to today's systems engineering methodologies for design, development, and testing – seem inadequate to systems which are orders of magnitude more complex and offer near infinite combinations and opportunities for diverse functionalities. Simply put, the most urgent task is to provide "technologies with sufficiently complexity:" the technology, systems, and concepts of employment required to sufficiently detect, track, target, engage, and assess at increasingly vast ranges and in increasingly complex environments, in addition to the tasks of linking information, and neutralizing threats. Efforts to address this "kill chain" often refer to the hazy prospect of 'Systems of Systems,' a level of integration that current software and data links both demand and theoretically permit. Regardless of whatever else the future holds, the present anti-access challenge necessitates an intensive integration of systems, sensors, platforms, and weapons that were not necessarily designed for congruency, but which possess an operational utility beyond the sum of their parts. It was offered from stakeholders that complexity science and novel thinking on complex adaptive systems are the disciplines that begin to address critical influences at scale in this larger context.

The technical branches of the Navy have come to understand the challenges of designing, developing, and fielding promising capabilities, but have yet to devise how to do so affordably and within declining budget-time-and-physical capacity constraints. Like any organization undergoing such trials, they can hardly be blamed for wondering how to accomplish more with less. Many lines of concurrent activity are difficult to manage effectively and there are tremendous fixed costs to developing effective decision-making structures. Moreover, highly talented managers and leaders are as scarce in the Navy and in government as they are in the private sector. Such super-managers, or management super-cultures, can handle a sixth line of activity more

effectively than other managers can handle a first. But they come at a high cost, and other measures offer helpful near-term expedients. At the very least, stakeholders believe that NAWCAD should engage more fully with the staff of U.S. Pacific Command (PACOM) which confront the A2AD challenge more directly than any other Navy constituency, and establish an annual beachhead at the PACOM science conference each March. PACOM's science and technology organization boasts embedded experts from the National Laboratories (Sandia and Livermore), University Affiliated Research Centers (UARCs), Federally-Funded Research and Development Centers, and other premier research and development organizations, like the Defense Advanced Research Projects Agency (DARPA). Some of the best current execution of systems development and integration, such as the true in-situ development of open architectural software systems, has emerged from industry, which forces the Navy and warfare centers to face squarely the implications of proprietary intellectual content, but which also draws usefully on well-established relationships and pathways. Stakeholders relay that partnerships and collaborations are critical.

This brief roster of measures will be not least among NAWCAD's challenges as it confronts the A2AD challenge. Many lines of research and development have been praised as yielding considerable dividends in efficiency and utility, most notably unmanned, networked and electronic warfare systems. Clearly, the organization should do more than position itself in the coming generation as the test and evaluation (T&E) and technology transfer (T2) agent for air-related A2AD technologies. By becoming *lead agents of systems integration, and reigning-in "out-of-control spec-creep," NAWCAD can position itself to radically shorten the time required to translate laboratory research into real innovations that are rapidly fielded. This may lend U.S. forces the slight, if temporary, technological edge required to succeed against adversaries who may well innovate just as fluidly*.

The technological and market-based economy of China is far deeper and more dynamic than that of the Soviet Union, which itself nurtured basic science and engineering research comparable to that of the U.S. The difference in the Cold War lay not in the quality of basic research and engineering, but in the effectiveness of the U.S. organizations – like NAWCAD, for instance – that rapidly adapted innovations to the operational marketplace. Future adversaries will likely grow in their adaptive skills and nimbleness, and NAWCAD will be challenged to become leaner, flatter, quicker, and more flexible.

Change is very hard for hierarchical institutions. Those interviewed reflected no easy answers and it was noted in the tone and demeanor of those interviewed that this will be hard work (but work worth doing). Fundamental organizational reform often requires discretionary funding, which is difficult to justify in a constrained budgetary environment. Change can also necessitate awkward cultural transformations, especially in large, diverse organizations comprised variously of civilian and military scientists, engineers, managers, and administrators. Yet, enterprise culture trumps strategy, as the perceptions and attitudes of the ones executing the strategies matter most. Stakeholders portrayed elements of prevailing cultural norms and it is worth understanding these perspectives. For example, personnel management and the growth of knowledgeable naval officers in key positions who are not deterministic decision makers are important considerations. Additionally, it is as important to educate civilian scientists and engineers to deal impressionistically (and using abductive vs deductive thinking) with the probabilistic environments in which both operate (e.g. fostering a collaborative environment for those who consider and actualize on meaning from A2AD scenarios and those who build technology is key).

While military organizations focus on training and readiness and are necessarily deterministic, scientists and researchers can assist in being creative and probabilistic, or motivated primarily by ideation. In this "scientist-engineer-military officer model," the scientist offers what is possible, the engineer determines what is practical, and the military officer determines what is useful. Rapid technological change will inevitably force military innovation organizations to confront the tiers of its conventional hierarchy – perhaps with the mindset to transform into "Skunkworks-like" teams – to solve problems more quickly, pointedly, and effectively, as some suggested in their interviews. In the end, if NAWCAD can find the resources, especially in the form of funding, time, and especially institutional patience, it may position itself as a highly regarded innovation leader within the U.S. Navy. In this sense, it would require: the wherewithal to experiment, iterate and create novel solutions; *the ability to leverage novel knowledge management tools to create robust decision support environments; and the foresight to embrace change*. This three-pronged strategy recognizes mistakes will be made, and in the process, game-changing solutions to the A2AD challenge may be uncovered.

Chapter 6

NAWCAD 2.0

NAVAIR and NAWCAD Background.

The Naval Air Warfare Center Aircraft Division (NAWCAD) is one of the U.S. Navy's Warfare Centers, located in Patuxent River, Maryland in St. Mary's County. It employs 3,000 scientists and engineers, with "unique R&D aircraft systems laboratories and test facilities, serving the needs of the U.S. Navy, as well as other services, federal agencies, foreign customers, and commercial entities," The complex at Patuxent River consists not only of labs and test facilities, but research and engineering professionals who work on air vehicles, propulsion, avionics, crew systems, and test and evaluation projects. In essence, NAWCAD advances and maintains the latest naval aviation assets for the DoD.159 The total business base for the organization in FY11 was just over $6B (160), with roughly 25% of that funding being research and development activity.

NAWCAD is a center of excellence for the Navy in naval aviation matters, and is looked to for critical support for a wide variety of naval aviation programs and naval aviation fleet activities. NAWCAD facilities support research, development, test, evaluation, engineering and fleet support of Navy and Marine Corps air vehicle systems and trainers. NAWCAD is the steward of the aviation ranges, test facilities, laboratories, and aircraft necessary to support the Fleet's acquisition and test and evaluation requirements. NAWCAD provides a variety of services to DoD, other Federal agencies as well as non-Federal customers.

NAWCAD is one of two product centers within the Naval Air Systems Command (NAVAIR). NAVAIR, working with industry, delivers high quality, affordable products and support to the operating forces. Products and services include: aircraft, avionics, air-launched weapons, electronic warfare systems, cruise missiles, unmanned aerial vehicles, launch and arresting gear, training equipment and facilities, and all other equipment related to Navy and Marine Corps air power. NAVAIR provides total life cycle support of all naval aviation weapon systems including research, design, development, and engineering;

acquisition; test and evaluation; training facilities and equipment; repair and modification; and in-service engineering and logistics support. As one of the three principal stakeholders in the Naval Aviation Enterprise (NAE), NAVAIR is responsible for research, development, acquisition, and life-cycle management for aviation systems.

The Environment in which NAWCAD Exists

It is important to note the local and regional conditions in which NAWCAD exists, as those conditions impact the organization's ability to not only attract, but retain critical talent and partner with proactive innovation networks that value technology transition. The State of Maryland is unique amongst the states in that it has the highest concentration of federal, and DoD workers in the country. Maryland is home to some 64 federal laboratories, including NIH, NIST, NASA Goddard, FDA, NOAA, and Fort Detrick, employing over 186,000 scientists and engineers[161]. The state has several major research universities, including The Johns Hopkins University (the nation's leading university in the volume of research), as well as the University of Maryland, College Park; University of Maryland, Baltimore; and University of Maryland, Baltimore County, which combined do close to $1 billion of funded research annually. Maryland is also home to the country's National Security Agency, and more recently, the DoD's Cyber-security Command.

As a result of these remarkable assets, Maryland ranks number one nationwide in R&D per capita and third behind only California and Massachusetts in the total volume of research.[162] The Milken Institute places Maryland second nationwide for technology economy preparedness, and with over 220,000 workers employed in professional, scientific, and technical service industries, the state is also second in professional and technical workers as a percentage of the workforce.[163] The challenge of this situation is that competition for technical talent in the region is high, especially for highly skilled technical workers in the science and engineering fields.

NAWCAD operates under what is called the "working capital model" which essentially means that it is supposed to operate similar to a business, in adapting and changing its workforce to market conditions, the market being primarily, but not exclusively the DoD. This model however has been implemented with artificial constraints, which can act to hinder the ebb and flow of operations necessary to serve our nation's national security needs. Over time, a series of constraints have been

levied on the warfare centers (limitations of overhead, carry over, and manpower ceiling constraints to name the most impactful restrictions) which constrains how effectively NAWCAD can accomplish its mission, including the exploration of innovative and novel solutions.

There has been much written recently on the challenges that large organizations face in "managing innovation." In particular, the Harvard Business Review published a series of articles by Scott Kisrner[164] regarding how big companies or large organizations stifle or even in some cases kill innovation. By their very nature, governments establish bureaucracies that can tend to standardize processes and stick with them vs. continually learn and upgrade to best practices. Consequently, paradigms remain in place creating an environment that does not necessarily embrace new ideas and innovation. Bureaucracies are no less pervasive in large defense industrial firms as well.

One of the issues facing DoD organizations like NAWCAD is that much of their business comes from a set of very large customers (the PEOs), who while interested in innovation, can also view innovation as disruptive to their product line execution orientation, or current programs. Thus, one of the major challenges facing the leadership of NAWCAD, and indeed NAVAIR and the Navy, is how to protect and nurture the innovative elements of the organization i.e. a culture of innovation, while executing their acquisition programs on-cost, on-schedule and on-performance.

One way some commercial establishments do this is to create sub-cultures and business units that separate their innovative elements from the main execution-focused company if you will, and let the innovation piece function semi-autonomously, continually feeding the execution arm with tried and true innovation that keeps them competitive. Innovation in defense has been shown to be facilitated by removing programs or projects from the organizational mainstream where operations are less risk averse and willing to explore new possibilities, fail fast and often, and push the envelope of understanding to new levels. Examples include DARPA's achievements as well as certain of the "rapid reaction" organizations established to address discrete technological challenges in Iraq and Afghanistan. One could attribute the success of classified (or "black") programs in the Cold War era as a function of the nonstandard culture or acquisition development environment in which they flourished. Similarly, some large defense firms have established advanced program operations to insulate them from the mainstream and foster innovation, such as Boeing's Phantom Works and Lockheed's Skunk Works. Another way is for the company to

create a culture of acceptance of innovation and how disruptive it can be. No matter what approach is taken though, all companies recognize that if they do not somehow embrace innovation, they face the prospect of obsolescence. In the case of NAWCAD and the Navy, it is imperative that there be a way ahead which allows innovation to flourish, as the competition is not over market share, but winning an actual battle when the time comes for such a fight.

Over time, new defense acquisition programs have become more complex than their predecessors in terms of their technology and functionality as a consequence of high-end challenges like anti-access area-denial environments. The relative increase in complexity is significant in its implications for warfare centers like NAWCAD. If transitions are gradual or small, then management and oversight processes and practices have more time to adapt. However, if transitions are large, there may be a significant mismatch between the complexity of the requirement to be addressed and the talent, skills, tools and methodologies within the acquisition program domain to address it, including the organizational capacity to manage the program effectively.

The analysis of the A2AD problem in previous chapters suggest that DoD has entered an era in which the complexity of the transitions from previous models of programs and weapons to those required in the coming years will be large, and those in contemporary naval aviation particularly large and potentially disruptive. Incorporating, integrating, and hardening state-of-the-art electronics, information technology, and software to provide critical capability have led to heavy reliance on technologies like sensors, data processing, automation, communication, and data exchange. Weapons increasingly consist of multi-faceted, multi-function, multi-mission systems that include many more specific performance functions than predecessor programs. Some programs, such as the first generation of semi-autonomous unmanned air vehicles (UAVs) have introduced entirely new capabilities. In a recent assessment of military programs, Robert A. Dietrick has pointed to the growing challenge of such complexity, especially to the rise of “systems of systems” (SOS), whereby discrete systems are coordinated through common integrated data networks. These integrated data networks and their protection becomes of paramount importance as they provide multiple entry points to SOS-wide vulnerabilities.165 Assuming adequate SOS protections are in place, a SOS architecture adds formidable capabilities greater than the sum of the individual weapon or sensor systems. *However, if the SOS integrated data networks become compromised individual “federated” systems will need to be capable of*

completing their mission independently or autonomously with limited communication.

The Navy Postgraduate School CRUSER initiative has identified the Network Optional Warfighting (NOW) as an emerging construct to address these concerns. These complexities present formidable challenges to NAWCAD, like the other technical centers of the DoD, in systems engineering, software engineering, and system integration. Dietrick defines complexity in terms of the number of interactions among discrete subsystems and their correspondent degree of integration, as well as the degree of integration at the component and part level, illustrated with examples in aircraft avionics, airborne sensors, and computer processors. He points out that increased complexity – necessary to enhance the functionality and capability of systems in increasingly competitive operational environments – strongly affects program cost, schedule, and performance outcomes. It is apparent that system complexity must be addressed at all levels of architecture and design leveraging concepts like modularity, open architecture, service-oriented architecture etc. which facilitate agility and adaptation while reducing costs and increasing capabilities by increasing competition and innovation.

This emerging complexity phenomena also needs to be reflected in organizational architecture, design, and it's concepts of operations in recognizing Ashby's law of Requisite Variety which states, "If a system is to be stable the number of states of its control mechanism must be greater than or equal to the number of states in the system being controlled" recognizing that "variety can destroy variety". The challenges of program management rise with the complexity of systems, requiring increased competence and depth of the workforce and an awareness that their large costs introduces a powerful political dimension.

A wide array of military, civilian, and contract personnel is essential to a range of functions throughout a program's lifecycle. No single public organization possesses the resources, capabilities, and political weight to execute the program fully on its own. As a result, they rely on industry for programmatic and technical capabilities like industrial base management, requirements revision, systems engineering, and system integration. To increase program control officials of three major contemporary programs – DD(X) (now DDG-1000), Deepwater, and FCS – have increased their access to variety and argued that they relied on industry for crucial aspects of program management because they did not possess the ability to manage such complex processes[166].

How can NAWCAD orient itself to change under the circumstances? The challenges of complex systems point to a need for strong leadership in devising concepts and technology, particularly in the systems requirements, architecture and integration functions, and in the people, the organization, and management structures that combine a widely diverse set of skills. As senior managers and technical staff at NAWCAD are well aware, the potential for information technology to replace manned with unmanned systems or provide new capabilities is in its earliest years. Yet, with the changes in the nature of the operational environment that A2AD presents, more rapid inventions, iterations, and adaptations will yield a higher payoff. Additionally, new concepts should be developed and tested at a smaller scale, such as at the program level, before wider application across the organization. For instance, if growing technical complexity in weapon systems makes cost, schedule, and performance increasingly difficult to predict, then the organization should be structured flexibly to make cost-performance tradeoffs and allocate funds across programs. Pilot programs – such as the initial JDAM (joint direct attack munition) pilot program or DARPA's Predator and HAE–UAV (high-altitude endurance unmanned aerial vehicle) – have shown some success with this approach.

OODA "Loops" and NAWCAD 2.0

In examining what a future NAWCAD might look like from an operating perspective, the notion of a "NAWCAD 2.0" emerges, where the organization adopts an ethos of being a complex anticipatory and adaptive system focused on environmental awareness, rapid- response, and innovation akin to a skunk-works-like prototyping, experimenting, and learning organization - one that is agile and intelligent enough to be the world class benchmark and leader operating within the emerging "global threats" OODA loop.

The OODA construct (Observe, Orient, Decide, and Act) is the work of a legendary fighter pilot John Boyd, who dedicated his life to translating fighter pilot tactics into a model in which a key attribute is moving through the OODA process in a timeframe faster than one's adversary[167]. The OODA construct, shown below, has been applied to not only pilot training, but to aircraft process design, as well as other engineering pursuits and business processes. It is felt that this construct is very applicable to the future operating environment in which a NAWCAD 2.0 will find itself, and thus a useful framework to examine

the necessary characteristics of what a successful NAWCAD 2.0 will look like.

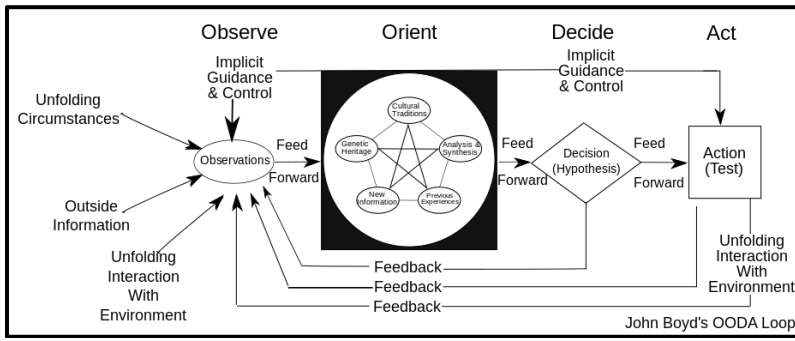

Figure 7. Boyd's OODA construct

Examining the individual pieces of the OODA analogy a bit more, in the observation state (OBSERVE), NAWCAD 2.0 is gathering information on the environment in which naval aviation assets will exist and perform. What is new about this element though is the need to be gathering information worldwide, rather than at a few discrete points as in the past. This is due to the global nature of rapid advances in both the science and engineering communities, and advancing business and operating models, as well as the global nature of prospective combatants. NAWCAD 2.0 needs a global sensor network and environmental understanding, with a major element of that sensor network being its own technical staff that can distill the meaning and make sense of advanced technologies and the rise of future elements of warfare more quickly than one's adversary. Removing barriers to awareness, learning and adaptation frees the organization from unnatural obstacles that can prevent the rapid realization of technology for the organization.

One of the cultural issues that will have to be overcome in developing this network is the perception within DoD that attending international conferences is an inefficient use of resources and not a priority compared to program execution. This mind set must be challenged given short, medium and long term demands so that government scientists and engineers are encouraged, and in some cases required, to attend technical and leadership conferences world-wide to nurture a knowledge dominance capability. There is simply no substitute for human realization and understanding, and one develops those insights, especially in the scientific and engineering communities, by interaction with one's peers, building social capital and forming the knowledge

creation, exchange and innovation networks across diverse sophisticated communities. Imagine the effect that would be realized if the 3,000 plus technical staff of NAWCAD were engaged globally in their various disciplines, and providing continuous feedback on what they are learning. Imagine further that this information is captured in a thorough fashion so that the organization can leverage it and actualize upon it. It would be made available to technical staff and leadership in a way that makes the information actionable and useful.

In the "Orient" state, the organization's culture and the ability to analyze and distill information come into play. There are two elements of this phase of particular note to NAWCAD 2.0. The first is the ability to be effective at assimilating large quantities of data, and being able to distill that data into information – down to what is critical and what is not. Both the government and private sector continue to develop such capabilities, and it is imperative that NAWCAD 2.0 have a robust in-house information synthesis capability, such as contained in emerging strategic "early warning" assessment and decision making tools. The second element of the Orient state has to do with developing scenarios, options, and possible courses of action. In the technical world this is efficiently and effectively accomplished through a design of experiments approach i.e. a well informed matrix of test conditions to explore hypotheses, and it is vital that NAWCAD 2.0 explore a variety of possibilities to their complex set of challenges.

The need to do hands on work, and conduct meaningful experiments or tests is one of the major reasons why having a suitable amount of discretionary funding available to the civilian leadership at Warfare Centers is vitally important (There is another, equally important reason that will be noted later). The very positive effects of giving a competent leader discretionary funding, and capable technical staff is well documented. In fact, the DoD has been attempting, with some minor success, to emulate a Department of Energy program called the "Laboratory Directed Research and Development" (LDRD) program, in which the Laboratory's Technical Director is given up to 6% of total incoming funding to use at their discretion. A GAO report168noted: 'DOE and laboratory officials …believe that the ability to offer innovative science work through the LDRD program helps attract new scientists who can eventually perform national security research work. Thus, these officials view LDRD projects—and the scientists they attract—as vital for national security in the long term.' "

One of the sources of discretionary funding for organizations like NAWCAD is the Office of Naval Research (ONR) budget, which in

2014 was roughly $2B.A bit of history on naval S&T funding is appropriate at this point. The first figure below shows the trend of how much Department of the Navy (DON) S&T funding (6.1 – 6.3 accounts) has gone to the Warfare Centers in aggregate. In 1992, the Warfare Centers received a bit over $700M, in FY11 dollars, or 46% of the Navy's total S&T budget. That amount had dropped to $440M in FY11, or 22% of the Navy's S&T budget. For the NAWCs, the second chart tells their specific story169. The bottom line is that the NAWCs have lost roughly 50% of their S&T funding over the past 20 years. The impact of this on NAWCAD's ability to experiment has been dramatic. These trends need to be reversed in order to ensure that the technical leadership of NAWCAD 2.0 has the necessary resources to experiment with new concepts in order to gain and maintain advantages for Naval Aviation.

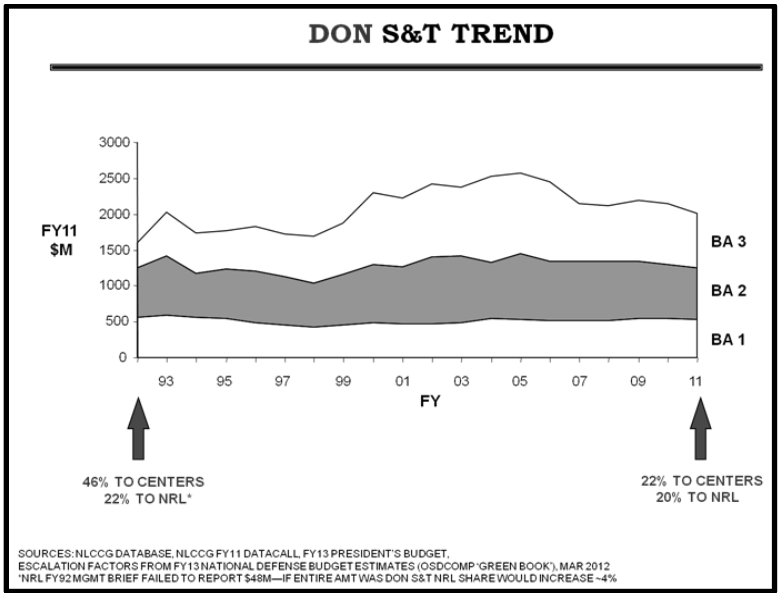

Figure 8. DON S&T Funding 1992 - 2011

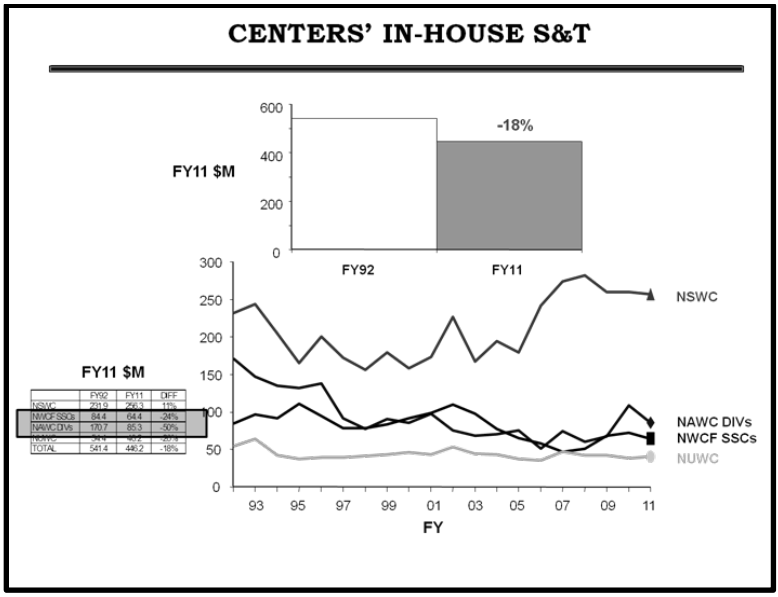

Figure 9. Warfare Center's In-house S&T funding 1992 - 2011

Many are familiar with Lockheed Martin's "Skunkworks" operation. "This operation was launched in 1943 when the U.S. Army's Air Tactical Service Command (ATSC) met with Lockheed Aircraft Corporation to express its dire need for a jet fighter to counter a rapidly growing German jet threat. One month later, a young engineer by the name of Clarence "Kelly" L. Johnson and his team of young engineers hand delivered the XP-80 Shooting Star jet fighter proposal to the ATSC. Quickly the go-ahead was given for Lockheed to start development on the United States' first jet fighter effort. It was June of 1943 and this project marked the birth of what would become the Skunk Works® with Kelly Johnson at its helm. Kelly Johnson and his team designed and built the XP-80 in only 143 days, seven less than was required. What allowed Kelly to operate the Skunk Works so effectively and efficiently was his unconventional organizational approach. He broke "the rules", challenging assumptions and the current bureaucratic system that stifled innovation and hindered progress."[170] This same sort of organizational mindset needs to be a major cultural element of NAWCAD 2.0, in order for it to operate as a critical partner and thought leader for DoD, as the U.S. military responds to future including unknown challenges.

The “Orient” state is also where the notion of a learning organization comes into play. Much has been written about the culture of innovative organizations, the culture of naval organizations, and the culture of innovative naval organizations. Suffice to say that the imperative for NAWCAD 2.0 is to have either the whole organization, or at least a well defined element of the organization be a true learning organization, and capable of rapid analysis, synthesis and assimilation of emerging information enabling continuous change and transformation. What does this mean from a practical day-to-day viewpoint? In the science and engineering business it is a well-established fact of life that becoming an expert in one’s field involves hands-on work, pure and simple. Thus, one of the features of a learning organization is that it is focused on “doing” and taking the time to reflect and subsequently improve, and not simply “heads-down” focused execution while “complying” with various policies, procedures and edicts. This is the other area where discretionary funding is vital, in that it permits the technical leadership of the organization to invest in the development of new, critical technical talent and organizational capabilities. While it is certainly true that scientists and engineers can learn many valuable technical lessons working on a large development programs, there is no better way for a young scientist or engineer to learn than to be part of a “hands-on” technical team tackling a particularly vexing problem. This discretionary funding is especially important in the attraction and cultivation of younger scientists and engineers, especially in the State of Maryland, where job opportunities abound for young technical talent. Giving new staff meaningful, exciting and challenging work is critical to developing a capable future workforce.

In the “Decision” state (DECIDE portion of the OODA construct) is where fusion of information and options are developed and addressed. As David Ullman notes in his paper on OODA Loops, “fusion can consist of both analytical and consensus building efforts.” It is for the moments of decision where assessment tools and methods described in Chapter 6 come into play. It is also where organizational elements such as the NAWCAD strategic planning cell are critical in helping to synthesize information for the whole organization.

One excellent example of how a strategic cell can provide great value is in the recent experiment to conduct a MMOWGLI (Massive Multiplayer Online Wargame Leveraging the Internet)**.** A MMOWGLI is a message-based game to encourage innovative thinking by many people, connected via the Web. It has been used to study a number of topics, particularly by the Naval Postgraduate School and in such endeavors as

how can the Navy prepare for the future of energy, starting in 2021 and beyond.

The overall MMOWGLI project was sponsored by ONR for the United States Navy. The goal of the project is to explore the potential of a war game leveraging the masses on the internet, with a variety of themes, to expand engagement in military and non-military strategy development for complex geopolitical problems. The platform is designed to support large numbers of distributed global players working together on idea generation and action planning, with an eye towards surfacing innovative outlier strategies. The 2030 Strategic MMOWGLI was conducted in September 2014 and was open to NAVAIR and NAWCAD employees, academia, and industry. Over 6000 invitations were distributed electronically resulting in over 640 registered game players. This resulted in over 5400 ideas generated from game play. These ideas were combined with in-house NAWCAD Leadership Team Strategic Off-Site inputs to create a comprehensive, broad and deep data set of strategic inputs. The data set was analyzed, synthesized and interpreted via qualitative research techniques and protocols using codes or labels which were integrated into eight top-level categories with representative subthemes and associated narrative descriptions to provide the essence of the results, along with 36 proposed Action Plans. These results provided the "feedstock" for NAWCAD Leadership deliberations in developing strategies and execution actions going forward. For further information on the results of the NAWCAD MMOWGLI please contact NAWCAD Strategic Cell.

Summary

This chapter suggests that the Navy needs in-house strategic innovation efforts focused on Naval Aviation to enable anticipation and adaptation to the environment. This organization must have the available time (Google gives each of its employees 20% of their time to "be creative"), freedom and funding to conduct risky and innovative scientific and engineering exploratory and experimental work.

This organization also needs to be acutely aware of the global activity in emerging fields of importance to naval aviation. This organization must value and create the concepts that the institution can activate and execute for sustained competitive battlespace advantage. This group will inspire the idea that it is a part of a continually learning and evolving organization, and that high value is placed on those most knowledgeable and innovative i.e. a meritocracy. Lastly, this organization must be

protected and allowed to invent, and seek innovation to make novel connections, even if that innovation results in disruption to larger programmatic interests within the Navy and DoD. This organization must be capable of operating in a highly dynamic accelerated OODA loop fashion, which includes respect for the implicit as well as explicit feedback channels necessary for learning to occur. This will set the initial conditions for the organization to foster the emergence of well-informed options for senior defense and national leaders that are as of yet, unimagined.

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[159] Retrieved from http://www.federallabs.org/labs/profile/?id=1358. The Federal Laboratory Consortium for Technology Transfer (FLC) is the nationwide network of federal laboratories that provides the forum to develop strategies and opportunities for linking laboratory mission technologies and expertise with the marketplace. They describe NAWCAD in this manner to all other federal labs and agencies.
[160] FY2011 Management Analysis Report for the NLCCG
[161]*The Effect of Federal Spending in Maryland, 2010*, by the Federal Facilities Advisory Board and DBED
[162]*Maryland R&D 2008: Meeting the global challenge for innovation*, by The Alliance for Science & Technology Research in America (Washington, D.C., 2008).
[163]*State Technology and science index*, by Ross DeVol and Anita Charwom, June 2008, Santa Monica, CA: Milken Institute; and *Educational Needs Assessment: Supply and Demand of Educational Programs Likely to Support the DOD BRAC Movements into Maryland*, by Regional Economic Studies Institute, Division of Economic and Community Outreach, 2006 (Towson University/Maryland Department of Business and Economic Development).
[164]Kirsner, Scott, Harvard Business Review, October 2013, "How Big Companies Undermine Innovation".
[165]Robert A. Dietrick, "Impact of Weapon System Complexity on Systems Acquisition," in James R. Rothenflue and Marsha J. Kwolek, *Streamlining DOD Acquisition: Balancing Schedule with Complexity* (Center for Strategy and Technology, Air War College, Air University, Maxwell Air Force Base, September 2006).
[166] Guy Ben-Ari and Pierre A. Chao, eds., *Organizing for a Complex World: Developing Tomorrow's Defense and Net-Centric Systems* (Washington, D.C., 2009) p.34.

[167] Coram, Robert, *Boyd: The fighter pilot who changed the Art of War*. 2002. P.344
[168]*National Laboratories – Better Performance Reporting Could Aid Oversight of R&D Program*, GAO Report 01-927, September 2001.
[169] FY2011 Management Analysis Report for NLCCG
[170] Retrieved from Lockheed Martin, story of LM Skunk-Works as posted to: http://www.lockheedmartin.com/us/aeronautics/skunkworks/origin.html

Chapter 7

Comments on Tools for Future Studies (like A2AD)

"The only thing worse than obsolete weapons in war is obsolete thinking." – Gen. James Mattis (Ret.)

The preceding chapters discussed the A2AD strategic background, the perceived operational context in terms of microeconomic and microeconomic factors (relative including capabilities & costing), historical A2AD / Counter Intervention grand strategies ("Historical Cases of Area Denial & Analyses" with macroeconomic state-level industrial preparation and responses), stakeholder perceptions based on interviews and views gleaned from published positions, and observations on the roles NAWCAD will need to play in the future to address emerging threats and operational scenarios. This chapter is focused on developing a tractable approach to encompass and use the information and knowledge derived from those and other sources for the purposes of assessments, comparisons and evaluations for the Naval enterprise.

To summarize and reframe the overall challenge in the highest level terms at an official level, we need to consider DOD's 2014 annual report to Congress171 which states:

> "In 2013, China announced a 5.7 percent increase in its annual military budget to $119.5 billion, continuing more than two decades of sustained annual defense spending increases. China sustained its investments in strategic forces modernization, as well as key anti-access/area-denial (A2AD) capabilities such as advanced intermediate- and medium-range conventional ballistic missiles, long-range land-attack and anti-ship cruise missiles, counter-space weapons, and offensive cyber capabilities. China's military investments provide it with a growing ability to project power at increasingly longer ranges. In 2013, this included at-sea testing of China's first aircraft carrier and continued development of fifth generation fighter aircraft."

This is a clear official recognition of the continually evolving A2AD challenge. The report specifically identifies "measures to deter or counter third-party intervention, particularly by the United States …. is manifested in a sustained effort to develop the capability to attack, at long ranges, military forces that might deploy to or operate in the western Pacific." The analysis of PLA writing points to information dominance or "information blockade" across all means to include electronic and information warfare capabilities, denial and deception, counter network operations, and operations both cyberspace and outer space. In the more traditional combat domains, A2AD looks to use a range of capabilities including Special Forces, ballistic and cruise missiles, maritime strike aviation, and surface and subsurface maritime combatants to hold U.S. and Allied targets at risk. The at-risk targets encompass fixed targets; air, sea, and space targets; and terrestrial targets ranging to the second island chain as well as the Strait of Malacca.

To obtain some direct 'ground truth' of relevance to the Naval Aviation Enterprise interests and concerns, ETC conducted the stakeholder interviews of Chapter 5 and dialogue with the study sponsors. There existed a noteworthy general assertion that at the center of an A2AD conflict is the *implied notion of losing one or more carriers*, and the *majority of air wing manned assets unless a viable "offsetting" strategy can be conceived and realized*. This represents not only a grave threat to naval aviation, but a vital threat to NAWCAD and the enterprise. To be successful, the "offset" strategy must incorporate a robust and resilient technology assessment and response. NAVAIR and NAWCAD must be positioned accordingly. It is also widely recognized that any technology response must include classified program understanding.[172] It is also acknowledged that a comprehensive study could include unclassified and classified perspectives from all Warfare Centers to promote coordination and integration ahead of demand.

The 'ground truth' discussions help in reinforcing the view and determination that the A2AD challenge must be addressed with all available planning and intellectual tools. Assorted forums, technical, and concept papers and studies have been devoted to identifying and exploring various risks and scenarios in detail. Our intent here is neither to add another specific scenario nor to create yet another table with a hypothetical order of battle. Our intent is to consider the A2AD challenge from a "comparative assessment" vantage point and recent understanding of the reality and impact of [usually] unanticipated emergent phenomena such as "Black Swan" and "Long Tail" effects. What one finds after massive military failures is that often massive

failure is often due to unappreciated biases, failure of intelligence interpretation, and conceptual limitations, rather than blatant technological inferiority. This is perhaps why there is so much attention devoted by the opposition to increasing 'information blockade', denial and deception, cyber ops, and C4ISR denial, in particular space based C4ISR platform denial.

It is instructive to look at Skypek's recent review[173] of classical "net assessment" [NA], In his view, NA is a multidisciplinary, comparative, diagnostic, and forward-looking framework for "evaluating the long-term strategic political-military competitions in which states engage" aiming to diagnose strategic asymmetries to identify opportunities "to support senior policymakers in the making of strategy."

The key message and point is focusing on identifying long-term trends to motivate exploration of alternative security futures. Skypek repeatedly points out the importance of defining a multidisciplinary framework, including any number of fields but vitally, economics, and organizational behavior. The key is simultaneous analysis of Blue and Red capabilities in order to identify strategic asymmetries and areas of advantage. It relies on a cleared-eyed assessment of one's weaknesses and strengths rather than solely aspirational statements. Skypek summarizes his appreciation of the NA technique in a table of with a notional outline of topic heading. This table is reproduced here as Table 7-1. 174

1. Political-Military Context for Analyzing the Competition
1.1. Trends in the Balance
1.2. Doctrinal Asymmetries
1.3. Analysis of Perceptions
1.4. Scenarios
2. Assessment of the Balance
2.1. Strategic Asymmetries
2.2. Environmental Opportunities
2.3. Impact of Third Party States or Alliance Systems
2.4. Issues and Questions that Require
Further Exploration

Table 3. Skypek's Outline for a Net Assessment

The classical pivotal Net Assessment questions, as Andrew Marshall, Director of OSD Office of Net Assessment formulated them[175], are:

1. Do we (the U.S.) have a problem?
2. If so, how big is it?
3. Is it getting worse or better?
4. What are the underlying causes?

It is also useful to look at what OSD's Office of Net Assessment is specifically currently examining. OSD specifically included the following words in a very recent Broad Agency Announcement (BAA)[176]:

> "The Office of Net Assessment conducts and sponsors analyses that compare the standing, trends, and future prospects of U.S. and foreign military capability and military potential. Priority is given to assessing aspects of the security environment and parts of the world that are likely to change in the future, and that may present threats or opportunities to the U.S. Assessments may focus on specific theaters, regions, functions, mission areas, major weapons categories, doctrine, etc., as well as on demographic, economic, and political developments that may affect the power and strategies of nations."

Perhaps one of the best known examples of Net Assessment is A. Krepinevich's assessment and report[177] on the Military Technical Revolution (MTR), later known as the Revolution in Military Affairs (RMA)[178].

While our purpose here is not to discuss the MTR/RMA study in detail, it is worth noting that Marshall, as OSD NA director in the introduction to the 2002 reprint of the study, re-iterated the purpose of the assessment being "to clarify and highlight what we thought were the most important of these strategic management issues."

Marshall's own words regarding what the most significant management issues facing the U.S. then were:

> • How to identify appropriate innovations? (Perhaps by means of future oriented war games, field exercises, forming experimental units, etc.)
>
> • How to foster true innovation? (Perhaps, by changes in career programs - introducing new career paths—military education, protecting and promoting innovative officers, etc.)

• How do we change the DoD acquisition process better to support field experimentation? (Perhaps by facilitating procurements of small quantities of experimental or prototype units.)
• How do we involve our allies? What role would they play? What would be the new division of labor between us?

Over two decades passed since those questions were posed and addressed; we find that the questions are still valid. In this section of our current study, addressing the current (for sake of discussion, 2014-2034) challenge focused on A2AD, one can debate if the U.S. will in fact find itself in a hot conflict with China. That is not the question for us to answer; *the reality is that China has been progressing on capabilities development and employment path that makes a viable A2AD challenge possible. The mere perception of viability is itself a strategic factor and may be just as effective a means to limit and constrain U.S. notions of freedom of navigation and ability to fulfill treaty obligations.*

For our purposes, the reframed and restated pivotal questions are:

A. Is the A2AD challenge in fact real?
B. What is the true magnitude of the challenge?
C. How can we identify and estimate the effectiveness of appropriate innovations?
D. How might this be developed for decision support?

The body of observations, information, analysis, and studies performed to date strongly suggest that the threat is in fact real. The construction and demonstrations of advanced Chinese military weapons and systems capabilities, and Chinese professional military literature discussing A2AD strategies and operations, are in fact the implied threat. Stated differently and more algorithmically, the governing mindset is the potential for the perception that IF [the opponent's tools to prevail in full conventional conflict] ARE [Reachable], THEN [the U.S. will yield earlier than 'hot' conflict initiation stage (knowing that it would entail unacceptable consequences as result of conflict)]. The prevention of this type of challenge maybe entail one of several paths, (a) demonstrating the economic consequences of a prolonged 'arms race' (emphasizing the collapse of the Soviet Union being due in large part to being unable to endlessly sustain the economic burdens associated with such an arms race), (b) development and demonstration of capability to prevail at a more intense level on the spectrum in order to deter and dissuade a

potential competitor from entering into a contest, and (c) other paths not currently clear enough to articulate.

A distinctly separate, perhaps overly alarming approach is to also fold in some of the more extreme conflict projections. In 2010, Alfred McCoy, Professor of History at the University of Wisconsin-Madison, penned an extremely provocative article in Salon Magazine. His article "How America Will Collapse (by 2025)"179 explores four 'end of the United States as we know it' scenarios. He argues that demise of the current order can occur very rapidly (citing the rapid demise of USSR and other recent empires such as the Ottoman Empire, the British Empire and others). His arguments are based on the confluence and convergence of economic, educational, technological and military indicators pointing to rapid decline by as early as 2020 and potentially critical, possibly irreversible point of no return by 2030. While assume this will be the outcome, we do suggest that scenarios, data, and indicators of this type should be part of an ongoing assessment, comparison and evaluation process (ACE process). Critical assumptions and data explored in scenarios as McCoy paints, should be made visible180. McCoy attributes U.S. decline to:

a. economic decline;
b. future 'oil shocks';
c. military surprises.

The economic decline is attributed to shrinking share of world trade, decline of technological innovation, and the challenge to and coming end of the dollar's status as global reserve currency. One of the pointers to serious technological decline is status in the "world's fastest supercomputer" race. Chinese supercomputers routinely capture the lead spot181 (and sometimes by wide margins). This particular aspect should be viewed as part of the cyber warfare challenge. Another, very recent development is the increasing Chinese emphasis on developing homegrown (Chinese sourced) computer operating systems182.

Closely coupled is the declining productivity of the U.S. educational system in the STEM space which when recognizing that many if not a majority of foreign-born hard sciences and technology graduate students in the U.S. are now likely to return home as U.S. economy becomes less attractive. The question of potential "reverse brain-drain" must be asked here as well. In establishing modern assessment warnings and indicators it would well be worth tracking human and intellectual capital movements and trends. One more factor to assemble, weight and contrast.

One can argue whether scenarios involving future 'oil shock' are realistic given current fracking technology and domestic natural gas abundance, but the global trends do point to China and India requiring more energy and Russia using oil and natural gas as an economic weapon. The National Intelligence Council in the report previously cited states "an energy transition, for example is inevitable; the only questions are when and how abruptly or smoothly such a transition occurs. An energy transition from one type of fuel (fossil fuels) to another (alternative) is an event that historically has only happened once a century at most with momentous consequences." If we accept this premise (and we should indeed; witness naval energy sources for propulsion transitioning from sail to coal to oil to nuclear), there are major consequences for U.S. Military forces and platforms. The economics and availability of fossil fuels for air platforms will require serious rethinking of all platform designs and logistics. With the exception of aircraft carriers and submarines, most military platforms rely on fossil fuels. Though there is significant ongoing research and development involving fuel cells and batteries, these have not been mainstreamed yet and do not scale for forces. Energy economics and technology must become a more prominent aspect of future military planning, and should be a core element of assessment studies and deliberations.

McCoy paints several military surprise scenarios. While there are various scenarios to posit, and many have done so, real events sometimes trump fictitious scenarios. Who would have thought that Russia would annex Crimea and engage in a shadow war in the Ukraine? The 'Arab Spring', Syrian Uprisings, and Islamic State events show that Persian Gulf and Middle East can flare up in truly unexpected directions. China is 'flexing' its forces and challenging the U.S. and its allies more frequently.

Another recent study worth learning from is Dean Cheng's Heritage Foundation BACKGROUNDER No. 2927183. Cheng argues that the "… Chinese military …has been incorporating a variety of anti-access/area denial (A2AD) systems and capabilities. These include not only weapons, such as anti-ship ballistic and cruise missiles, but also political warfare methods, including legal, public opinion, and psychological warfare techniques. To counter these A2AD capabilities, the United States needs to adopt a comparably holistic approach, incorporating political measures, operational military deployments, as well as technical counters". Cheng's reading of the Chinese activities and approaches indicate the U.S. must develop a fundamental

understanding of the Chinese thought processes. It is relatively easy to review and evaluate technology, weapon system development/ acquisition, and force structure. It is much more difficult to understand the full cultural national context and toolset that will be employed in an A2AD based contest.

Cheng identifies some of the dimensions of the contest beyond the focus on tactical A2AD (i.e. China's focus on limiting impact of adversary air attacks). Cheng brings out a contest that utilizes a "layered approach encompassing strategic, operational, and tactical elements, employing all the instruments of comprehensive national power to prevent an opponent from bringing airpower to bear against the PRC." He discusses the lengths to which China is expected to engage in the softer but highly strategic non-traditional warfare elements, namely Legal warfare, Public opinion/media warfare, and Psychological warfare. He places the operational A2AD warfare level with Information and Space Dominance Operations. Cheng emphasizes that one must expect application of Unified forces. Employment of unified forces are expected to involve integration of civilian and military space systems and unifying space forces with land, sea, air, and electromagnetic forces in joint operations. Cheng offers several mitigation approaches, however, our intent here is not to advocate a particular approach, but rather to inform of the complexity of the issue, the range of thinking, and range of suggested solutions, and the need to create an updated holistic approach to explore significant A2AD and similar challenges with particular focus on Naval Aviation issues.

This is of course a very high level outline for a comparative assessment. Paul Bracken, Professor of Management and Political Science at Yale University, and formerly on the senior staff of the Hudson Institute views combined or "net" assessment as a practice. In a paper in Parameters, Bracken states "The best way to define net assessment is to understand that it is a practice. It isn't an art (like military judgment), nor is it a science (like chemistry). Rather, it's a way of tackling problems from certain distinctive perspectives that involve skills that can be improved."184 LTCOL Paul Maykish, co-author of C2, Cross-Domain, and JSTARS doctrine, characterized185 Bracken's six practices that form a framework of net assessment as:

1. Strategic interactions
2. Long time spans
3. Getting things right with a little thought
4. The importance of socio-bureaucratic behavior
5. Strategic asymmetries
6. The multifaceted nature of strategy

Table 4. Paul Bracken's Framework of Net Assessments

It is worth repeating Bracken's concluding remarks concerning net assessment; "In place of "modeling complex and thinking simple", net assessment tries to "model simple, and think complex". The spirit is one of using relatively simple models, numbers, and trends, and to think long and hard about what they mean." This is something we will return to, namely, the notion of comparative simplicity of models and complexity of thinking. For example, from simple initial conditions very complex situations and circumstances may emerge. The key notion implied here is that if one misses completely an important factor, it really doesn't matter to how many decimal points one can model a capability.

Sam Tangredi, a recognized A2AD expert, devotes an entire book186 to exploring A2AD in ancient, historical and current settings. Tangredi pays special attention to General Dempsey's (Chairman, Joint Chiefs of Staff -JCS) Joint Operational Access Concept187 (JOAC) and vision for how joint forces will operate in response to emerging anti-access, and area-denial security challenges.

The central thought in the JOAC is cross-domain synergy of a complementary nature vice merely additive. In addition the JOAC calls for synergetic employment of capabilities at lower echelons to generate sufficient tempo to successfully exploit fleeting local opportunities. The JOAC illustrates the cross domain synergy by providing these examples: "airpower to defeat anti-ship weapons, naval power to neutralize air defenses, ground forces to neutralize land-based threats to air and naval forces, cyber operations to defeat space systems." The JOAC also identifies the key required capability categories (joint functions) as: Command and Control, Intelligence, Fires, Movement and Maneuver, Protection, Sustainment, Information, and Engagement.

Tangredi analyzes each of his exemplar A2AD scenarios in terms of the JP-5188 (Joint Operation Planning) Phasing Model and what he finds

to be five fundamental elements of the A2AD strategies throughout history, namely:

1. perception of strategic superiority of the attacking force,
2. primacy of geography,
3. predominance of the maritime domain in the conflict,
4. criticality of information and intelligence (and conversely, operational deception)
5. determinative impact of extrinsic events (and seemingly unrelated events).

Tangredi also provides lists and tables of techniques to counter or preempt A2AD. These are not repeated here. However, it is useful to keep these in mind as elements of high level NA tools that can be combined and used to evaluate via specific technical processes and methods.

The critical importance of the JOAC and the A2AD challenges, and concern about approaches for meeting the challenges are getting elevated national attention as seen in the recent Government Accountability Office (GAO) study189. This study was in response to a congressional mandate to review the role of the Army and Marine Corps in access-denied areas. GAO specifically states "The Department of Defense (DOD) is *unable to gauge the extent* to which its efforts to overcome operational access challenges support the implementation of the 2012 Joint Operational Access Concept (JOAC). ... DOD may lack assurance that efforts (including those currently being undertaken by the Army and the Marine Corps to address areas such as engagement activities, entry operations, logistics, and expeditionary missile defense), will fully align with the JOAC." GAO specifically and repeatedly calls for means of assessing and measuring progress with respect to meeting the challenge of A2AD and the goals of the JOAC.

It is useful in this regard to also display the context which GAO uses to frame the A2AD challenge. The study's first figure [GAO-1-801: Figure 1] displays the following:

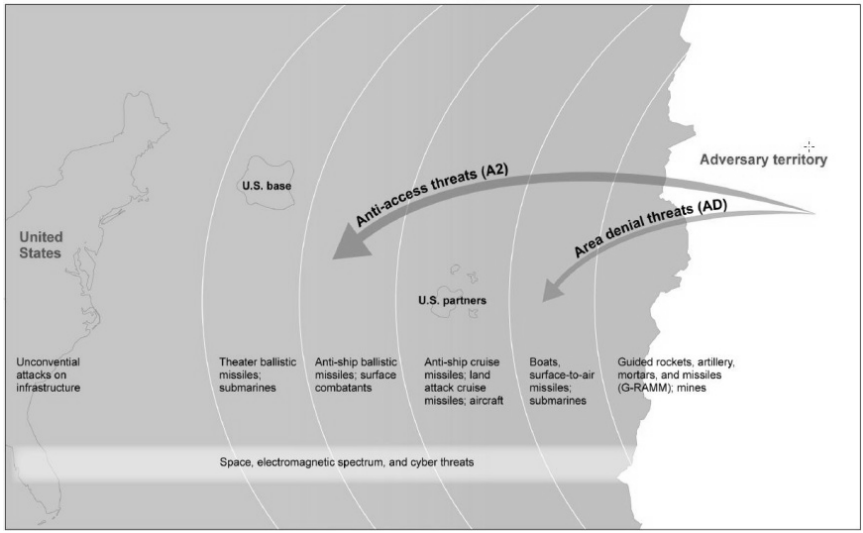

Figure 10. GAO depiction of Anti-Access and Area Denial Capabilities Examples based on its analysis of DOD information.

In view of the variety of thinking and approaches exploring A2AD issues, there's a clear need for an overarching approach to both consolidate perspectives and enable granular explorations of A2AD mitigation approaches and strategies. The solid experience and utility shown by Andy Marshall's analytical and war-gaming experiences argue for the utility and advisability of building on the classical net assessment approach to create a formal tool that blends economic modeling and simulation with technological comparisons and even military and other analyses. This type of comparative and evaluative tool would enable wide ranging technical modeling and simulations that allow objective quantifiable assessments.

War games are indeed useful for exploring certain aspects of inquiry and for gaining insights, but war games are participant dependent, weak on objective reproducibility, and hence not as powerfully convincing as objective tools190 (unless patterns and correlations can be derived from multiple wargames independently conducted over time).

There is an opportunity for Naval Aviation and NAWCAD to pilot an A2AD Assessment and Concept Evaluation (ACE) capability. ACE would allow NAWCAD and leadership organizations (e.g. ASN (RD&A)) to rapidly visualize challenges such as the A2AD challenge - the details (at any drilled down, or classified level) and mitigation approaches - to deeply understand, conceptualize solutions, and evaluate feasibility and likelihood of technological and military success of

proposed solutions. The elements and parameters to consider for an ACE capability should include:

1. Global Alliance Dimensions
    a. Allies - Historical and lasting - those we see eye to eye with and share values, goals and methods,
    b. Allies - Situational (Operations/Tactics/Technologies)
    c. Coalition members – for a limited duration
2. Economic Dimensions
    a. Microeconomic factors
    b. Macroeconomic factors
    c. Economic 'Black Swan' factors - these have yet to be sufficiently well articulated, but having seen the impact of these (2008-2013) it's clear that some accounting for their occurrence take place
    d. Automation, Robotics, and Artificial Intelligence. There may be better words to express these, but clearly the potential for massive productivity and innovation discontinuities abound in this category. Some look at the concept of the Singularity (where machines attain greater than human intelligence capability. IBM's Deep Blue beat world chess champion Gary Kasparov; IBM's WATSON computing architecture trounced the all-time Jeopardy champions. Individually these are slivers of intelligence that outperform the most talented humans in prescribed domains. The time is coming where a single machine will outperform the most talented humans in a range of domains.
    e. Major Technology and Leading Corporations. Right now the U.S. leads in 'incubating', fostering, and maturing planet-wide technology driving corporations (in no particular order) like Xerox, HP, Google, Microsoft, Apple, Intel, AMD, Amazon, IBM, Facebook, and Oracle. There of course other major broad technology companies like 3M, Boeing, GE, Westinghouse, AT&T. Some of the companies mentioned are already in their sunset days (Xerox). The question here is really, are these companies facing technology and 'world dominance' challenge and are Chinese companies overtaking them? Note for example that Lenovo displaced IBM in the PC market (essentially buying out IBM's interests there). It is of significant interest as a technology and economic

'indicator and warning" to track long term 'contracts', mergers and acquisitions in these areas.

3. Domestic Political Dimensions
    a. In the United States - one can conceive of political Black Swan events where a faction with views substantially orthogonal to the main stream emerges and captures the attention and is favored by significant numbers of highly motivated and active citizens (not unlike the Tea Party).
    b. Political Black Swans in the competing nation – altering their traditional political norm and calculus.
4. Revolutionary Breakthrough Science – much in the same way that Electricity and Electromagnetics, Quantum Mechanics, Relativity and Atomic and Nuclear Physics and Chemistry saw amazing and revolutionary developments around the turn of last century (circa 1900), it is entirely possible that 'un-programmed 191' / unanticipated radical changes my occur in the sciences. Note that in this category, there are numerous perspectives on revolutionary / game changing technologies. The Global Trends 2025 report192 identifies three likelihood categories (Probable, Possible, and Plausible).
5. Computational dimensions and in particular cognitive computing, computer hardware and software design, and self-modifying software design.
6. Military Technical Dimensions extending to global and extra-global (perhaps earth-moon system and beyond) scales:
    a. Planned and near-certain technology advances:
        i. Next generation conventional geographical global systems (traditional theater scale systems + long range aviation such as next generation B2 type bombers, hyper endurance / very high altitude solar powered glide assist bombers).
        ii. Prompt Global Strike (Mach 20+ hypersonics, intercontinental conventional warhead ballistic systems)
        iii. CYBER (This is a multifaceted category that appears in many discussions. It is both critical in its own right, and an enabler to many other functions and missions, and merits its own specialized study and investigation).
        iv. SPACE (Satellites and Space Based Systems)
        v. Social (Facebook, Twitter, Main Stream Media, etc.)

   b. Global scale phenomena modification (e.g., tampering with the ionosphere)
   c. Tampering. (E.g. with trajectories of solar and extra-solar matter, e.g. vectoring meteorites and asteroids). While these ideas sound extreme today, it may be possible to shift the trajectory of a relatively small body and make it appear to be a totally natural phenomenon. It is true that today it is very difficult to predict point of impact, but this may be possible especially if one utilized dynamic vectoring to aim such bodies. A major catastrophe can set the U.S. back years to decades (or more) based on the magnitude of impact and create an overall economic and military imbalance that 'takes the U.S. out of-play'.

7. Non-Traditional Warfare Dimensions. These are different from the asymmetric warfare notions of the past.
   a. New faces of Terror Warfare. Current example are ISIS in Iraq, Hamas in the Gaza conflicts, Implied terror [as exercised by Assad in Syria and pro-Russian forces – for example the Ukranian conflict examples of downing of civilian aircraft and access to Russian Spetznaz 'little green men' and current generation weapons to terrorize lesser equipped Ukrainian forces.
   b. Demographic Warfare. This is a subtle and less appreciated form of warfare, however it is possible to predict demographic conditions into the future, since the majority of the 'warfighting / able person' population of twenty years hence are essentially already born. It is easy to predict the age profiles and demographic profiles of contestants given their population demographics today. This enables understanding warfighting 'manpower' and societal burdens year into the future. Coupled with technology forecasts and educational attainment forecasts one can paint a picture of how 'conflict/war ready' the population will be.
8. Systems and Complexity based warfare:
   a. Systems and Network Complexity
   b. Ability (Skill) to cope with complexity
   c. Degree of Systems and System of Systems Interoperability and Integration
   d. Ability (Skill) to cope Systems Interoperability and Integration

9. Unrefueled Range for tactical aircraft and hybrid-missile systems.193.
10. Pre-conflict interventions (including soft actions)
    a. Cyber
    b. Financial
    c. Criminal
    d. Mercenary

Fundamentally, one looks to understand the correlation of strategies, operational concepts, and technologies that will be brought to bear, and given the result of the 'unperturbed' path (U.S. present course and speed), are these capacities sufficient to 'assure' success in the future. If not, what should we (U.S.) be doing about it?

Assessment and Concept Evaluation (ACE) Capability

The challenge in evaluative assessments is to capture succinctly but comprehensively all the factors that may matter (which is a complex and unbounded task), and at the same time, present a coherent clear synoptic view that allows rapid appreciation of balance of capabilities. There are a number of approaches as discussed earlier in the chapter. All of them have good points; the difficulties are primarily in tracing the chain of logic, the detailed inputs, the aggregating process, the evaluation process, and the summarization process into a comprehensible and transparent comparative assessment.

In conducting this study, it emerged that there would be high payoff both at the NAWCAD level and at the national level to employ standardized well, understood processes and tools that culminate in a single well understood process and display to depict the assessment at any instant in time. Upon reflection, it appears evident that the overall ability of the United States to prevail in serious, perhaps existential, conflicts, is dependent on physical, economic, and social material as well as the conceptual tools with which we both arrive at and use the physical material the concepts we employ or have at our disposal. With that in mind we conceptualized an Assessment and Concept Evaluation (ACE) capability and an ACE display approach described below.

The approach we recommend pursuing is designing and developing an ACE framework at a national level, since in a superpower conflict we would utilize all aspects of national capability. With a national level framework in place, one can then particularize to NAWCAD specific areas of concern, and then particularize even further to NAWCAD A2AD relevant considerations. The danger of starting and staying at a

low level is that one may fail to see the interconnected nature of many elements of consideration, and then be in a position of strongly advocating a particular path that in reality is not a significant element of the overall consideration. Working across levels of generalization and hierarchies allows one to rapidly gain a sense of comparative relevance and significance, that in turn facilitate appropriate decision making and investments supported at the service and national levels.

The essential aspect is to culminate with a top level synoptic ACE Display that can easily be comprehended and discussed, with a functional ability to 'drill down' to expose the details of the steps that lead to the top level display. Fortunately, with today's computer and display capability, linking multiple hierarchical levels is straightforward. The detailed evaluation components at every level can be as simple or complex as desired. One can use simple formulas or simulations requiring supercomputers. The key is to be able to attribute information correctly and obtain either quantitative or qualitative measures from the subordinate detail level, and then consistently roll these up to the higher level with traceability for the 'rules' of rolling information up to the next level. Some specific examples are provided to illustrate this approach. One should keep in mind though, that this is a notional/conceptual framework, and a functioning ACE would need to be designed and developed to actually be utilized.

At the top most level we recommend a synoptic qualitative display with three primary 'gauges'. We term the 'gauges' indicators, with the three being a) strategic indicator, b) operational indicator, and c) tactical indicator. The indicators are shown in the form of gauges with the traditional RED, YELLOW, and GREEN regions for ease of immediate apprehension of the value and significance of a particular indicator. A needle pointing in the GREEN zone obviously means that the United States is comparatively in 'good shape' relative to that area of consideration, needle in the RED obviously means that the United States is comparatively in 'bad shape' relative to that area of consideration, and YELLOW suggests that the matter is not clear cut. One can easily make a more complex time tracking display displaying time history trace of the where the needle was at various points in time. This is slightly more complex and can provide more insight into historical trends and whether the United States is improving or receding in capabilities. Other refinements can also be included.

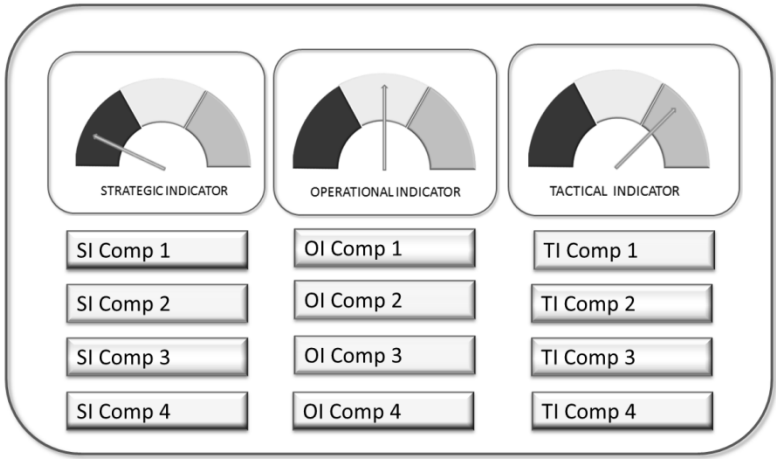

Figure 11. Notional Top Level View of ACE Display

Figure 11 shows a very simple notional top level ACE Display with the top-most indicator being a gauge with a needle indicator, and a set of 'component' indicators shown as colored areas under the gauge. The Figure 11 example shows 4 component indicators under each gauge. The actual number of components is likely to be different in the final design. The main points here being that the top level indicator would be indicating some weighted combination of the component indicators, and the name and qualitative value of the component indicator would be immediately visible. For example, one component indicator might be "Nuclear Weapons Ready for Launch", and the value of the component indicator would be the result of comparison of U.S. /Adversary's "Nuclear Weapons Ready for Launch" (NWRL) with U.S. overmatch showing as green and Adversary overmatch over U.S. showing in red. Another component indicator might be displaying comparative Cyber Warfare condition.

We conceptualize that the format of the display be a web enabled display allowing 'clicking' on the component indicator 'buttons'. Clicking on the component indicator buttons would then bring up the next level information. Each component indicator would itself be a weighted combination of the subcomponent elements that makeup that component indicator. With the NWRL example, one could look at subcomponent indicators being land based nuclear weapons, air launched nuclear weapons, and submarine launched nuclear weapons, with each of these having a comparison algorithm for evaluating the U.S./Adversary balance and providing an indicator.

A detailed design of a ACE tool would need to incorporate the networked logic for each major system in terms of Weapon vs. Weapon, Weapon vs. Countermeasure, Weapon Logistics (primarily in terms of it being in theater or needing to be brought into theater), Weapon Readiness (this includes training, spare components, repair-ability), and possibly other considerations. For example if we look at a CVN as the weapon system, than we would need to examine the balance of CVNs, CVN vs. anti-CVN weapons, etc.

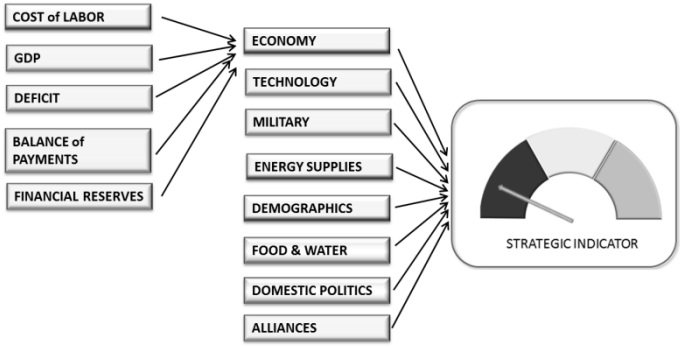

Figure 12. Notional Decomposition of an ACE Economy Indicator

Figure 12 depicts a possible notional decomposition of an ACE Economy Indicator as a component of the Strategic Indicator. In this case, the Strategic Indicator of Figure 12 was decomposed into 8 subcomponent indicators, with "ECONOMY" being one of the subcomponent indicators194. The Strategic Indicator would then be some combination with appropriate weighting of the subcomponents. The ECONOMY subcomponent is then shown with its own subcomponents (cost of labor, GDP, deficit, balance of payments, financial reserves), with each subcomponent being depicted with a particular color/status value; these values are purely arbitrary and are shown just for illustrative purposes. What is important is to recognize that as the ACE tool and display decomposition becomes more detailed, each constituent subcomponent can and should be connected and derived from a rigorous model and possibly simulation. The suggestion being is that use be made of existing models and simulations where reasonably accessible and available (or otherwise estimated by a simple process).

One should also keep in mind that many conflicts are scenario dependent, so in developing an evaluation and assessment matrix, the

individual displays shown above need to be customized to particular scenarios of conflicts with particular nations. The analyses of individual scenarios contain their own set of complexities. Two reports, separated by more than a decade, illustrate some of the considerations useful for inclusion. The earlier report195 set in the Persian Gulf looked at U.S. interdiction capabilities in the presence of anti-access strategies. Specifically, it discussed a specialized model used for mission system analysis aimed at identifying critical enablers of early-halt capability such as immediate command-control, intelligence, surveillance, and reconnaissance; interdiction; and weapon effectiveness. That study utilized a custom made RAND model called EXHALT (an interdiction model for exploring halt capabilities in a large scenario space).

The more recent report196, considering U.S. Army operations in Asia in the 2030-2040 timeframe, suggests consideration of US /China friction, contest, and possible conflict associated with China's interests in South China Sea, the Philippines, and Vietnam, Japan and the East China Sea, Taiwan, Korean Peninsula, India, conflict over maritime claims, as well as Chinese conflict with India or Russia. The latter is one not on many analysts future-cast screens, however the developing Russian demographic vacuum in the Far East, at time of increasing Chinese population is one that bears watching, especially in light of the fact that at the end of the day in the previous two world wars U.S. aligned with Russia.

These reports suggest that there's great value in fact in conducting comparative assessments in both retrospective and prospective modes. A Retrospective Comparative Assessment (RCA) would allow factual and historical review of major conflicts and issues with an eye to understanding the pivotal elements of what in fact contributed to success and resolution of major issues. For example, despite the 'seemingly simple' calculus of A2AD threats (such as the DF-21 'carrier busting' maneuverable reentry warhead ballistic missile), past experience shows that ingenuity and innovation can overcome serious challenges. Barry White in a recent CSBA report197 cites discussion about some successes arising from the Long Range Research and Development Planning Program (LRRDPP) investments. In particular, citing the compelling case that long range precision-guided sub-munitions (PGSM) would be highly effective. In fact, experts and military leaders on both sides (NATO and Warsaw Pact) estimated PGSM effectiveness against Soviet follow-on echelon forces to be comparable to low-yield nuclear weapon effectiveness. This shared perspective ultimately allowed re-thinking European defenses in conventional terms with much fewer if any theater

nuclear weapons198. The lesson to be learned from the PGSM history is that confluence of innovative technology and strategy can dramatically shift perceived battlefield advantages.

Another aspect that is worth discussing is developing innovative U.S. asymmetric capabilities that do not go “head-to-head” with a particular weapon system or network, but that do exploit or could create unacceptable vulnerabilities in the opponents national system199. When we explore future scenarios, we’re in fact exploring a family of Prospective Comparative Assessments. PCAs can and do have a variety of possible future to explore. The nice thing about the past is that there’s really only one past (with many interpretations), but the future is contingent on many factors, many of which are not even articulated or known until perhaps decades and centuries later.

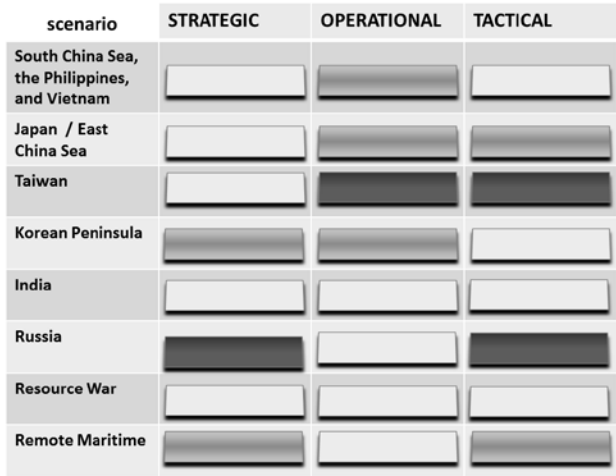

Figure 13. Individualized (Prospective) Scenarios Assessment Matrix.

As one of the correlating displays for the ACE, one should consider an individualized scenarios assessment matrix as depicted in Appendix 2. In this display, one would be able to view the synoptic measures as related to individual scenarios. In this case the entries are {China + China Allies} vs. {U.S. + U.S. Allies} in particular scenarios. We do not assume that either China or the U.S. will have the same Allies in each case, and each conflict alliance creates its own dynamic as well as advantages and disadvantages (do note that the color entries are fictional and are for illustrative purposes only, and no policy should be developed as a result of the color table in Figure 13.)

When particularizing the assessment displays for NAWCAD, care should then be exercised to actually determine what specific NAWCAD competencies participate in which conflict scenario elements, and whether the NAWCAD competencies and facilities should participate more intensively in area requiring more intensive U.S. capabilities development.

Figure 14. Retrospective Comparative Assessment Matrix

Figure 5 depicts a Retrospective Comparative Assessment matrix. It depicts top level assessments for a spectrum of conflicts. The world wars can be decomposed into individual theaters and campaigns, and retrospective assessments can and should be conducted for each (for reasons that are left to another time.) Similarly, the Cold War has its own entry and so do Vietnam, the Korean War, and the Cuban Missile Crisis (all of which can be considered as components of the Cold War). Each also deserves a RCA so we can fine tune the RCA methodology and develop an accepted and shared approach for assessments. It is worth noting here that the components indicator no doubt will be different in retrospective and prospective assessments, and from the comparisons of RCAs and PCAs one can develop a better appreciation of what the governing tactical, operational, and strategic indicators and indicator components are.

One can and should develop automated tracking and technology sub indicators to track intellectual capital development in scholarly areas. There are many ways to organize a list of scholarly topics. **The table in Appendix 2 shows a recommended subset of major technology areas and subtopics derived from Google Scholar200 metrics list.** This is a

partial list of topics chosen for most relevance to comparative assessment issues. The general categories of Business, Economics & Management, and Social Sciences and their subcategories are also available but were omitted at this time. Google also provides the h5 metric201 with each sub area and the listing of the most cited papers and their individual h5 metric. Please see Appendix 2 for details.

If one looked for further details, for example looking at the top cited journal, Aviation & Aerospace Engineering, Google Scholar would provide the following discrete information202: Title / Author, Cited by (count of citation), and Year of publication. **The top 20 are also noted in Appendix 2**. For illustrative purposes the top three journal papers, their citation, and citation metrics are provided.

- Flow Separation Control by Plasma Actuator with Nanosecond Pulsed-Periodic Discharge, DV Roupassov, AA Nikipelov, MM Nudnova, AY Starikovskii, AIAA Journal 47 (1), 168-185 (2009), [cited by 156].
- Optimization of Dielectric Barrier Discharge Plasma Actuators for Active Aerodynamic Flow Control, FO Thomas, TC Corke, M Iqbal, A Kozlov, D Schatzman, AIAA Journal 47 (9), 2169-2178 (2009) [cited by119].
- Correlation-Based Transition Modeling for Unstructured Parallelized Computational Fluid Dynamics Codes, RB Langtry, FR Menter, AIAA Journal 47 (12), 2894-2906, (2009), [cited by 117].

This by itself doesn't provide definitive final information. These indicators are indicators of Intellectual Capital. The next step would be to look at Intellectual Property as measured by patents. Patenting is a rather expensive process, and (typically budget conscious) organizations and institutions expend significant resources on patenting only after they satisfy themselves that there is economic and industrial merit to the Intellectual Capital. Also, patents typically indicate a level of maturity suggestive of readiness or near readiness to a technology transition phase with more mature design and fabrication intended. Exploring the aggregate statistics of various countries provide additional indicators that merit inclusion in comparative assessments. Yet additional insights into technology progress can be gleaned from economic trend analysis specifically examining new company startup trends and investment capital flows into startups and innovations.

While this study is not a technology subsector Comparative Assessment, it is worth pointing out that several technology areas play and will increasingly play disproportionate foundational roles for all

engineering areas that should be tracked carefully. In particular, two areas stand out, computer hardware and software design are of paramount importance in their contributions to facilitating progress. With the basic fact that all complex engineering design requires computer based analyses, design, and simulations, the following should be kept in mind:

- Those who can compute faster will complete the design faster
- Those who have the better self-evaluating and self-modifying software will win the design innovation race.
- Those who have both the faster computers and the better software will eventually trump everyone else.

Right now, China has the largest/ most powerful (by FLOP count) supercomputer. It has maintained the lead in the supercomputer race for a number of years (review again the data in footnote 9). It is not yet the leader in computing technology, but is poised to become so. Accordingly, it is highly recommended that a computing technology specific Comparative Assessment be undertaken with specific assessments as to national security and defense implications.

While a stand-alone NAWCAD ACE would be very useful, it would be even more useful to think in terms of a national level/DOD level ACE, one should consider at least a Department of the Navy level ACE tool (even if initiated at the NAWCAD/NAVAIR organizational level). One can of course develop and use a NAWCAD ACE to guide strategy and an investment, however working at a service department level allows naval leadership to really understand the context of the entire service capabilities and portfolios, and to be able to make useful choices. Just as one doesn't enter conflict with only one weapon system, one should not consider only one weapon system at the time. With that in mind though, for NAWCAD to benefit significantly, the level of detail covered in the sub-indicator analysis would need to include at least the current and projected technologies, systems, missions, and their associated functions.

A good starting point for NAWCAD is with a detailed, system engineering oriented, functional allocation of operational systems and systems in acquisition in the Naval Aviation pipeline, as well as the intended opponent targets for the operational and 'in-development/acquisition' of these systems. The technologies, systems, and their functional and mission allocations are likely already available in a form used by Warfare Area level combat simulation tools. Investments are recommended to realize the ACE capability; and these investments should go to: identifying the governing components and subcomponents to third (preferably fourth) level, designing the

framework and displays, developing an adjustable method for weighting and combining the components and subcomponents, user-interfaces, and developing a prototype (or at least an initial prototype capability, to be followed by development of a full prototype for the areas of NAWCAD relevance). It should be noted that some of the components and subcomponents may be linked (possibly non-linearly and recursively in feedback loops) as elements such as cost of labor and technology appear in the general economy as well as in cost and affordability of weapon systems.

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[171] DOD ANNUAL REPORT TO CONGRESS: Military and Security Developments Involving the People's Republic of China 2014

[172] Many stakeholders had to filter their knowledge to respond in an unclassified manner – identifying more work to be done.

[173] Skypek, TM, *Evaluating Military Balances Through the Lens of Net Assessment: History and Application*, Journal of Military and Strategic Studies VOLUME 12, ISSUE 2, WINTER 2010

[174] The outline is a reproduction of Skypek's outline from his 2010 paper. There he states" each of the four pillars of net assessment is represented in the outline. The exact order of the pillars is immaterial and depends on the preference of the assessor. The basic analytic output of a net assessment has some basic parallels to the SWOT (strengths, weaknesses, opportunities and threats) analysis methodology developed by Alfred S. Humphrey at the Stanford Research Institute and used widely in the business world. A SWOT analysis highlights an organization's internal strengths and weaknesses along with external opportunities and threats. The key differentiator is the integrated assessment of Red and Blue capabilities and the process of understanding how each competitor perceives the other."

[175] Marshall, A, *National Net Assessment*, memorandum, 10 April 1973, discussed by Skypek.

[176] See HQ0034-ONA-13-BAA-0001 Broad Agency Announcement for the Office of the Director, Net Assessments. The specifically named areas for NA in the BAA: Future Naval Warfare, Proliferated world, Space, Sustaining Current Areas of US Advantage, History (Military), and an open ended Additional Research Topics that address unprescribed topics including such as the future security environment, and possible alternative futures.

[177] Krepinevich, AF, *The Military-Technical Revolution: A Preliminary Assessment*,' Prepared for the Office of Net Assessment, (Washington, DC: Center for Strategic and Budgetary Assessments 2002. This document is a reproduction of the MTR Net Assessment conducted in 1991 and 1992, and published in 1992; it was reproduced with an updated forward to allow wider circulation.

[178]Interestingly, the term 'Revolution" is used often without placing it in context of the ongoing flow of revolutions that include the *Industrial Revolution* accelerated by availability of the *steam engine*, the Agricultural Revolution (accelerated by mechanization, synthetic fertilizers, pesticides, and foundational understanding of genetics), the Health and Medical Revolution accelerated by understanding of sanitation, germ theory and sterilization/disinfection of medical tools, and anesthetics. Of course recently, the Cyber Revolution [aka information age] has facilitated a range of revolutions. What we appear to be in is a continuing stream of 'revolutions'. The military and defense disciplines finally recognizing that developments accumulate into noticeable jumps or discontinuities that sharply separate those who participate in the military technical revolutions and those who don't.

[179] Alfred McCoy, *How America will collapse (by 2025)*, <http://www.salon.com/2010/12/06/america_collapse_2025/>

[180] McCoy and others base their interpretations on substantive data and official reports such as the National Intelligence Council's *Global Trends 2025: A Transformed World* (ISBN 978-0-16-081834-9), Director National Intelligence Report NIC 2008-003, November 2008. Washington D.C.

[181] See < http://www.computerworld.com/article/2491467/high-performance-computing/china-has-the-fastest-supercomputer--but-the-u-s--still-rules.html> (Jul 2, 2014). The article states "China

continues to lead the benchmark list of the 500 most powerful computers: Last week, the country's Tianhe-2 supercomputer was cited as the world's No. 1 system. Capable of speeds of up to 33.86 petaflops (33.86 quadrillion calculations per second), it has held that distinction for a year. The Tianhe-2 was built by China's National University of Defense in collaboration with the Chinese IT company Inspur. The supercomputer uses Intel processors, but China has created its own chips and has started building large systems with entirely homegrown products." This computer has approximately twice the capability of DOE's - Oak Ridge National Laboratory TITAN Computer according to the data at < http://www.top500.org/list/2014/06/ >.

[182] See http://www.reuters.com/article/2014/08/24/us-china-technology-idUSKBN0GO08H20140824 *China targets own operating system to take on likes of Microsoft, Google*. This, and similar articles, point to the China's official decision to limit use of the Microsoft Windows 8 Operating System and to move away from Western sourced operating systems. There are several vectors of concern and alarm that should be raised here. Primarily, if China is indeed successful in this endeavor, it will be much more difficult to conduct offensive cyberwarfare.

[183] Dean Cheng, *The US Needs an Integrated Approach to Counter China's Anti-Access/Area Denial Strategy*, Heritage Foundation BACKGROUNDER No. 2927, July 9, 2014, Washington, D.C.

[184] Paul Bracken, *Net Assessment: A Practical Guide*, Parameters, Vol. 36,90-100, (Spring 2006).

[185] Paul J. Maykish, *Strength In Ways: Finding Creativity In Routine Strategy Development*, Thesis, School Of Advanced Air And Space Studies (SAASS), Air University, Maxwell Air Force Base, Alabama, June 2011

[186] Sam J Tangredi, *Anti-Access Warfare: Countering A2AD Strategies*, Naval Institute Press, Annapolis, MD. 2013.

[187] Department of Defense, *Joint Operational Access Concept (JOAC)*, VERSION 1.0 17 January 2012, <http://www.defense.gov/pubs/pdfs/joac_jan%202012_signed.pdf>

[188] Joint Publication (JP) 5-0, Joint Operation Planning, < http://www.dtic.mil/doctrine/new_pubs/jp5_0.pdf>, 11 August 2012

[189] DOD Needs Specific Measures and Milestones to Gauge Progress of Preparations for Operational Access Challenges, GAO-14-801: Published: Sep 10, 2014.

[190] One can easily challenge results of a war game, it's much harder to challenge a formal mathematical / algorithmic simulation, and it's almost impossible to challenge an accepted 'law of physics' [the challenge being restricted to the question of whether it's the correct domain and initial/boundary conditions].

[191] By unprogrammed we mean activities that are not part of any institutional or programmatic plan, thus being substantively invisible to decision makers and program managers. Obviously any valid breakthrough will gain immediate attention once it occurs, but until that point no resources will have been reserved for exploiting the breakthrough. The nation(s) that can quickly incorporate such breakthroughs into their major programs stand to have a significant advantage over laggards.

[192] The report uses input from SRI Consulting Business Intelligence and Toffler Associates to identify these Game Changing Technologies and their likelihood. *Probable:* Ubiquitous computing, clean water technologies, energy storage technology. *Possible:* "Biogerontechnology" (science related to the study of the cellular and molecular basis of disease and aging applied to the development of new technological means for identifying and treating diseases and disabilities associated with old age), Clean coal technologies, human strength augmentation technologies, and biofuels technology. *Plausible:* Service robotics (comprising robots and unmanned vehicles for non-manufacturing applications), and human cognitive augmentation technologies (drugs, implants, virtual learning environments, and wearable devices to enhance human cognitive abilities).

[193] Biddle, S., *The past as prologue: Assessing theories of future warfare*, Security Studies, 8(1), pp 1-74,1998, <DOI:10.1080/09636419808429365> provides the example for ground attack aircraft of unrefueled combat radius of 2,000 kilometers 1990's contrasted with less than 500 kilometers in the 1920's. Similarly he cites "a maximum of less than 100 meters for 200mm armor penetration by direct fire antitank weapons in the 1930s to more than 6,000 meters by 1980; from less than 10 kilometers for tube artillery in 1900 to more than 250 kilometers for missile artillery in the 1990s".

[194] While the choice of the categories was not random, it is somewhat artificial, and the orders and actual use of categories should be regarded as purely notional, as well as the status/color indicator evaluation for them.

[195] RAND Corporation Report MR-1471-AF, *Measuring Interdiction Capabilities in the Presence of Anti-Access Strategies: Exploratory Analysis to Inform Adaptive Strategy for the Persian*, Gulf by Paul K. Davis, Jimmie McEver, Barry Wilson (2002)
[196] RAND Corporation Report RR-474-A, *The US Army in Asia, 2030-2040*, by Terrence K. Kelly, James Dobbins, David A. Shlapak, David C. Gompert, Eric Heginbotham, Peter Chalk, Lloyd Thrall (2014)
[197] Barry D. Watts, *Nuclear-Conventional Firebreaks and the Nuclear Taboo*, Center for Strategic and Budgetary Assessments, Washington DC, 2013
[198] This may yet change again with Russia's new found 'interest' in using very low yield weapons to now compensate for its declining conventional capabilities.
[199] For example, a system or network that would force the opponent to deal with significant domestic issues such as degrading the means by which an opponent suppresses a restive internal minority.
[200] http://scholar.google.com/citations?view_op=top_venues&hl=en Accessed 29 September 2014.
[201] Per Google Scholar, "h5-index is the h-index for articles published in the last 5 complete years. It is the largest number h such that h articles published in 2009-2013 have at least h citations each."
[202] This specific data set was obtained on 29 September 2014.

Chapter 8

Conclusion

This study was launched to highlight and offer new knowledge gained from the exploration of future A2AD scenarios, with particular emphasis on critical implications for NAVAIR and NAWCAD. The deliberate exploration of scenarios such as A2AD has yielded keen insights not only for the highest levels of strategic defense planning, but in particular for the U.S. Navy and its institutions. For example, NAVAIR and NAWCAD can use A2AD scenarios to challenge knowledge and trigger innovative recombination of designs that might address complicated and challenging national security puzzles in novel ways. This is wise before designs arrive on the world stage. NAWCAD stands to gain considerable advantages through the continued examination of A2AD and other high-end scenarios. This keeps the air-fleet of the future properly capable in any scenario. Inherent in the process of strategic thinking and A2AD scenarios is the notion of a touchstone for that debate. The alternative is our loss of advantage through the failure to understand future threats to the institution, above and beyond those to U.S. forces or allies.

Foresight can be leveraged by exploring plausible national security circumstances via game-play. Finding correlations, patterns and possibilities in game data can lead to the identification of new and novel opportunities. Scenario experimentation and exploration can lead to the conditions for information and decision making advantages and the vectoring of knowledge throughout the institution as a continuous feedback mechanism. From that knowledge, the institution can assist robust and resilient designs for the Naval enterprise. ***No matter which world events set the course for the future – the goal is clear – readiness of institutions must occur in parallel with the readiness of U.S. forces***. These types of activities should also lead to exploration of novel sets of synergistic solutions for the Naval force and its institutions – ones that can more conscientiously prepare the U.S. Navy for whatever adversary it might face in the future – from inhospitable weather to near-peer conflict.

This study sought to analyze the intersection of three ideas – economic context, technological advancements and military planning. The focus was knowledge of A2AD presently residing in the minds and perspectives of leaders within institutions such as NAVAIR, and an exploration of A2AD historical situations with a focus on the economic elements of national power (from both macro- and micro-economics perspectives). These factors uniquely inform context and help to build plausible scenario sets. The game play of stressful scenarios such as A2AD helps set a novel course to the future for U.S. Naval institutions– including NAWCAD – by examining potential decision points.

A2AD scenarios of this study were principally viewed through the lens of DoD institutions such as NAVAIR and NAWCAD. Several contextual elements summarize the emergent patterns from the perspectives of DoD leadership on A2AD, as well as from the economic analyses conducted. For example, as viewed through the lens of A2AD in the Pacific:

- Increases in China's defense budget could stem from needs for modernization and personnel improvement to safeguard China's homeland and press disputed regional and maritime claims. Chinese weapon systems also serve as anti-access armaments that discourage third-party intervention. A rising, but ambiguous percentage of China's defense budget is spent building and deploying destroyers, frigates, subs. This could be seen as measures addressing anti-piracy, protection of shipping, or providing domestic shipbuilding jobs; it also raises concern for the United States and its allies because of the possible A2AD threats the growing Chinese fleet could pose.
- Chinese defense spending is increasing at a double digit rate per annum. The published Chinese defense budget for 2014 is $132 billion, but transparency issues, off-budget purchases, and budget omissions may mean that Chinese defense expenditures exceed $180 billion. Using DoD estimates and conversion factors, the Chinese defense budget is equivalent to $300 billion in U.S. dollars, a 227% increase since 1989.[203] If current trends persist, the Chinese defense budget will equal the current U.S. defense budget in purchasing power between 2021 and 2025 and will double U.S. defense budget purchasing power between 2028 and 2033.

- If China's defense budget continues on its current progression, the current level of A2AD capability that China possesses will potentially reach critical thresholds. This may lessen U.S. ability to control the six major domains of possible military competition (maritime, air, ground, space, cyberspace, nuclear and command and control).204 China will likely increase its capacity to challenge U.S. strength in several domains simultaneously. The U.S. must contend with many unknown factors pertaining to China's crisis comportment, domestic nationalism, and elitist views. The subsequent dynamic might prove unstable unless the U.S. alters major aspects of our political and security strategic thinking with respect to China.
- Comparative assessments, and Comparative Analyses and Evaluations would better help DoD to understand Chinese military modernization and related budget issues. Monitoring economic indicators, social media, Chinese domestic politics and regional shifts will add insights on Chinese defense budget growth and allocation. Purchasing power parity studies would highlight correlation between growing gross domestic product and growth of the Chinese middle class. These studies can help correlate and predict future Chinese defense budgets in the context of competing Chinese national interests. Alternatively, leveraging asymmetric and novel approaches as discussed in this study could enable improvements in deterrence and warfighting capabilities by changing the risk calculus.

Additionally, historical A2AD analogies and perspectives helped shape the context for macro-economic viewpoints with respect to A2AD scenarios. It is clear that China has observed the U.S. imperative of access, yet they have also observed historical analogies for A2AD (such as Britain's struggle to regain the Falklands in modern times amidst A2AD-like circumstances in Argentina). Macro-economic analyses and positioning can also assist thinking for the Naval enterprise. For example:

- The distinguishing characteristic of the U.S. – Chinese strategic competition is the unprecedentedly high degree of economic interdependence that defines the interaction.

- China's trade as a percentage of GNP has soared from 13 percent in 1980 to 40 percent by the late 1990s, and China holds 23 percent of privately held U.S. public debt, the largest share of any foreign holder.
- Interdependence is seen by policy-makers in both countries as fundamental to peace and stability, and has led to the expectation of ongoing mutual gains through expanded trade.
- A balanced scholarly assessment would hold that economic interdependence and relative strategic power interact to shape the posture of China and the United States toward one another.
- Engagement enhances the quality-of-life of millions of Americans and cushions the impact of debt-fueled government financing. But it also helps China grow and modernize in relative economic terms.
- If translated into military capability and strategic importance, Chinese economic growth will reduce the costs and risks of a more muscular Chinese strategic policy, if not actually provoke expansion. Adding shocks such as world-wide depression to tight economic couplings heightens risk (WWII analogy).
- Interwar Japanese policy (pre-WWII) is an historical analogue. Officials long supported an emphasis on growth through peaceful trade, as against expansion through conquest, which posed considerable risk and costs. The Great Depression and western sanctions (shocks to the system) brought forth reductions in trade and lowered expectations for future growth through trade, and made military expansion more attractive (remaining assets such as military capability can be a valid choice in vital circumstances). With an economy heavily dependent on access to imported resources and overseas financial and export markets, contemporary Chinese leaders face a growth and modernization challenge starkly analogous to that of Japan in the interwar period. (Fragility of the system when exposed to shocks like the Great Depression may precipitate military use – and scenarios can be built to examine similar conditions).
- As growing competiveness diminishes expectations of gains through trade and cooperation, a sphere of economic influence in Asia will become essential to the stability of the Chinese regime and the country's security.

- We must be accordingly mindful of *miscalculations* on both sides about the intentions and vulnerabilities of the opposite party, bearing in mind that each has a strong interest in altering their exposure to the relationship and reducing their vulnerabilities.

The aforementioned set of circumstances, constructs and situations set the context for our study, mainly in terms of economic and historical foundations of the world. Stakeholders of DoD institutions and other national security experts were interviewed –including Pacific-theater national security professionals, Naval Warfare Center leadership, strategic leadership (including flag leadership, both current and retired), and NAVAIR leadership. The results were insightful and indicate there *is a growing concern at all levels that there is a pervasive erosion of advantage and capacity to act in light of the full-range of possibilities associated with A2AD scenarios*. Particular insights include:

- Across-the-board consensus: With respect to A2AD scenarios at scale, *U.S. Naval Aviation has not witnessed this level of potential contest since WWII*, and naval units attached to a platform will be highly challenged (in particular the carrier and its air wings). *The carrier will be challenged from all domains.*
- Appreciation of the *unique Maritime aspect of the A2AD challenge exists* (from the initial battle for seaborne access, to sea-basing, sustainment and execution in theater - with mission sets from ISR, logistics, protection, fires (especially cross-domain fires), and establishment of freedom to maneuver.
- Agreement from the majority of stakeholders interviewed that the current approach includes four discrete contests: *information acquisition and verification, in-theater staging and basing (including sea-base establishment and base-defense), undersea advantage, and precision strike.*
- Recognition that *Naval Aviation platforms and systems are primary and visible targets*, which have inherent limitations and potential vulnerabilities.
- Appreciation of novel A2AD elements (cyber [both offensive and defensive], and space-based [C4ISR and anti-satellite]) *The implication is that many units will be cut off, misinformed, and likely operating at commander discretion*.

- *Geopolitical alliances are a vital component of the 'solution'* ("Allies" present a major complication, however, "lack of allies" presents an even bigger complication).
- *A2AD technology insights: unmanned systems, high-endurance platforms (w/low-fuel requirements), next gen surface technologies (e.g. rail guns, e.g. to launch counter-A2AD micro systems), novel C2 and software approaches, directed energy weaponry, hypersonic weaponry, and advanced sub-surface systems (e.g. sub-launched/recovered aviation assets)* are novel counter-A2AD technologies highlighted by experts interviewed. Technology however, needs to be balanced by the recognition that if technological superiority is the default response, and if U.S. depends on that response unduly, when the technology fails, the battle will be lost based on the tight-coupling.
- "Acquisition warrior" focus has emphasized bureaucratic mechanics of acquisition over hard science and engineering competency. *Program management now trumps novel technology development*. Technology development has in large part been driven out of Warfare Centers and acquisition organizations contributing significantly to the overall reduction in innovative capacities (vs. capabilities)
- *Response to losing one or more carriers, and the majority of air wing manned assets has yet to be fully thought through for the naval enterprise*. This is to understand what notional competitive disadvantage looks like.

(Note: It is widely recognized that any technology response must include classified program understanding. Many stakeholders had to filter their responses to remain "unclassified "– identifying more work to be done. Also, a comprehensive study should be done to include A2AD and counter-A2AD perspectives from all Warfare Centers for coordination and integration. This should also be completed with a classified annex.)

Several implications became recurring and prevalent for the Naval Aviation enterprise with implications for NAWCAD from the historical and economic context, in review of the stakeholder's analyses. *The Navy needs a true "in-house innovation engine" focused on Naval Aviation.* This organization must have the freedom and funding bandwidth to conduct risky and innovative scientific and engineering work. It must be aware of the global activity in fields of importance to aviation within and

beyond DoD. It must value its concepts for continual learning and change management. It must be able to transform and transition value when it is found. This "NAWCAD 2.0" is based on those most knowledgeable and innovative places in this country who conduct themselves in this manner (i.e. meritocracy). Lastly, *this NAWC AD 2.0 organization must be shielded and allowed to innovate, creating disruptive value-added concepts to enable the Navy and DoD to adequately support Naval Aviation institutions, let alone warfighting*. This ***"NAWCAD 2.0"*** must be capable of operating in a highly dynamic OODA-inspired fashion, where the organization has built-in anticipatory options for senior defense and national leaders based on objective data from the series of pro-active, scenario-based simulations and analyses for the Naval Enterprise, that are as of yet unimagined.

In conclusion, it is worth highlighting the long-term undertones from the recent 2013 study on the topic of China and A2AD by the Carnegie Endowment for International Peace:

> "An Unsustainable Status Quo: Given the uncertainties and risks associated with the future evolution of the China-Japan-U.S. security environment, approaches could encounter serious obstacles to implementation. As a result, decision makers in both Tokyo and Washington will probably be tempted to avoid making many of the hard choices required over the next fifteen to twenty years (especially for the robust forward presence and defensive balancing approaches) and opt for some variation of "business as usual," involving only marginally greater levels of U.S. presence and virtually no significant change in allied and region wide policies and political relations. However, considering current and probable future economic, military, and political trends and events in China, Japan, and the United States, such conservative status quo policies and strategies are unlikely to remain capable of ensuring a stable security environment conducive to U.S. and Japanese interests over the long term."205

This study points to the need for an integrated capability to assist in understanding the various perspectives, technologies, situations, reports, and elements of national power and their confluence (with the character of that of the Carnegie Endowment study). There is also a significant

need for a community of strategic thinkers with advanced modeling and simulation tools for integrated strategic assessments; that include scenarios such as A2AD. This capability would yield impactful insights from the tactical to the strategic. It would be designed for warfighters, DoD decision makers and technologists alike. Insights generated from fusion-engines of that sort begin to set foundations for thinking through Andrew Marshall's mandate (former director, DOD Net Assessments), in order to be able to answer four very important questions he posed:

1) Do we (the U.S.) have a problem?
2) If so, how big is it?
3) Is it getting worse or better?
4) What are the underlying causes?

The goal is to be able to ask and answer, at all levels of leadership, a fifth question – "What do we do next?" Several higher order concepts that have been presented on the nature and character of such a modeling and simulation tool stand out as important conclusions from this study:

- Modern comparative assessments and unanticipated emergent phenomena ("Black Swan" and "Long Tail") analyses suggest ***massive failure is often due to unappreciated biases*** within an organization or institution, *failure of intelligence interpretation*, and *conceptual limitations, rather than blatant technological inferiority*. Game-play breaks down these informational barriers.
- Insights from this study indicate this capability must be multidisciplinary, comparative, diagnostic, and possess a forward-looking framework to diagnose strategic asymmetries and areas of advantage with attention to economics, organizational behavior, and simultaneous analysis of Blue and Red capabilities. Developing scenarios with stakeholders greatly assist insights on the future. ***Insights enable foresight***.
- The most significant management issues are designing solutions to: foster innovation wisely, identify appropriate innovation early, aid the DOD acquisition process to better support field experimentation, and involve stakeholders, including industry and allies.

This study has brought forth many contextual and foundational-level concerns for DoD, the Navy and NAWCAD: economics & budgets, military expansion of countries like China, and serious technological

competition, such as in the supercomputer race (e.g. cryptology, cyber warfare, 'big data', cognitive computing, unmanned systems management and simulation based design and testing implications). The degree and significance of these reflections is yet undetermined at Naval enterprise levels for DoD.

In sum, a strategic assessment capability (like ACE – "Assessment and Concept Evaluation Tool as highlighted in Chapter 7) would allow NAWCAD and many other leadership organizations (e.g. Warfare Centers, ASN (RD&A), OPNAV, NWDC, NWC, ONR etc.) to rapidly visualize and evaluate long term strategic A2AD challenges, details, biases and risk mitigation approaches. Doing so would permit NAVAIR and NAWCAD 2.0 to grow and sustain a U.S. national security competitive advantage, which merges scientific, engineering, operational and organizational talents and considerations. In the end, coordinated offset strategies can be developed at various scales, and knowledge can be vectored appropriately. This flows from a strategic assessment capability that will hedge against bleak possibilities and unwanted outcomes such as those currently presented by scenarios such as A2AD.

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[203] Office of the Secretary of Defense, "Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2014". Ft. Belvoir: Defense Technical Information Center, 2010.

[204] Swaine, et. al., China's Military – The US Japan Alliance in 2030, Carnegie Endowment for International Peace, 2013.

[205] Swaine, et. al., China's Military and the US- Japan Alliance in 2030, Carnegie Endowment for International Peace, p. 24-5.

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APPENDIX 1:

Stakeholder reflections and perspectives

Considering the survey questions and an A2AD scenario for planning purposes, the data from the participants perspectives were gathered. *Note: Non-Attribution applied. The following are offered as a debate of the ideas, versus a debate of who stated them.*

- "[High Cost aviation acquisition programs] are soaking up all the money. In 1944 and 1945 the fleet lost 5100 carrier-based aircraft, and 1900 land-based aircraft, with over 700 lost in Okinawa operation alone. The fact that we are going to produce a low number of new aircraft each year, for the next few years renders consideration of attacking mainland China ludicrous. There will be only 2 JSF squadrons with 2 super-hornet squadrons until 2030. Currently China, India and Russia have 12 hot aircraft production lines open between them."
- "The [forces] are completely unrealistic in planning on hitting targets deep in mainland China. There is no way to do this in my mind. Do [the forces] think we are just going to "roam" around China and take these targets out?"
- "The NAWCs should be addressing is the convergence between Cyber and EW. Offensive and defensive cyber domain work and networks, integrated fire control in an EW/Jamming environment are the investments we need to make."
- "Folks at NAWC's have to be extremely aware of programs that are funded." The context is the power of the incumbent programs and an incremental approach to the future versus an approach to revolutionary innovation.
- "Working with [warfare centers] is difficult. Their default is always to ask "what about ship risk, or what about aircraft risk? Who is asking what about fleet risk?"
- "Acquisition system seems broken. The amount of time to get a program through a milestone decision is ridiculous."
- "We are at an inflection point regarding impact of technology on warfighting capabilities, and the capabilities of potential adversaries." Something or someone must straighten things out internally or when a war breaks out, the mayhem will be the impetus for change.

- "The military is being stretched too far, and getting involved in many important, but non-military roles." This interviewee felt this was a mission creep, and only going to get worse.
- "The biggest future challenge is complexity. We are in a phase where we know our systems are complex, but still trying to figure out how to design, build, maintain and use, (in a cost effective fashion), complex adaptive systems. This especially applies to future software systems."
- "We need to plan for unexpected consequences, and we are not doing much of that."
- "Stovepipes" are not in all cases a bad thing, because some parts of an organization must focus, very laser-like, on having technical depth to solve tough problems." There are good stovepipes and ones that detract.
- "Industry generates good ideas." As if to point out "how" are we harvesting and working with industry? What is the nature of the relationship between industry and DoD with regard to novel solutions?
- "There is but limited knowledge of NAWCAD specifically and limited understanding of who they are, and their role. It seems to be just one more part of the NAVAIR competency organization, and not some unique part of NAVAIR." This was mentioned in the context of NAWCAD being merely an acquisition competency for test and evaluation, not a competent, "skunk-works-like" center for novel solutions.
- "Demonstration projects reduce risk in the programs; the F/A-18 has done a good job in this regard." Where have all our innovative demonstrations gone?
- "Within NAVAIR, 'if they build it, it will become a requirement:' if a unique testing facility is constructed for a particular program, it seems like every ensuing program has to go through some sort of testing in that facility."
- "The challenge that we are now facing – and will continue to face in the coming years – is that of "Systems of Systems Integration and Complexity". There is a vulnerability of kill chains, end to end. As we move into the Anti Access Area Denied (A2AD) battlespace – our task is to provide the technology, systems, and concepts of employment to detect, track, target, engage, and assess at increasingly growing ranges, in increasingly more complex battlespace – with the platforms

and weapons we have today and those with which we continue to develop - synergistically. I do not see a deliberate [A2AD] contribution from NAWCAD in this regard."

- "The solution to this problem set is the integration of sensors, platforms, weapons, and communication paths. This is HARD. The systems we develop today are software intensive. We are dealing not with the complicated technical development efforts of a generation past that ushered in today's systems engineering methodologies in design, development, and test – but with systems that are orders of magnitude more complex – with near infinite combinations and opportunity for functionality not designed in or desired. Add to this the revolution of Systems of Systems Integration that our software and data links are allowing us to now exploit – and that the A2AD environment is compelling us to exploit – and now you have increased this order of magnitude yet again – attempting to tie in systems, sensors, platforms, and weapons that were not designed together, at the same time, nor with the purpose of being exploited in this synergistic way. And not only is the challenge to design, develop, and field these capabilities – but to determine how to train to these tactics and capabilities – and to do so affordably and within the roughly the same training constraints of budget, hours, airspace that we generally live with today. This is our challenge today, and with the coming generation."
- There is a complex problem set for NAWCAD and others, with no easy answers.
- "These challenges are encapsulated in efforts like Integrated Fire Control, Navy Integrated Fire Control, A2AD employment, Integration and Interoperability, Integrated Warfare Capabilities, Live-Virtual-Constructive, Proficiency Optimization, and others. These names you are hearing more and more of are to accomplish the tasks I just talked about."
- "<u>We are on the ground floor of this revolution of connectivity</u>. We are just starting to write the book. Success is an absolute must, in order to maintain our technical, tactical, operational, and strategic military advantage (which is eroding). Anti-Access is complex, and evolving threats and battle space, that are demanding. It is a must not only for capability, but for capacity and affordability as well. Any aircraft, any sensor, any weapon, any time is what we've been talking about and we are now going

there. The technical challenges are many, but achievable by engaging the institution to solve it."

- "The need for highly talented, skilled, motivated operators with tactical, technical, management, and leadership skills continue to be a must – and represent the shoulders of those with which we stand on today that have come before us and given us the wonderful machines and capabilities that we employ currently." Once you have them, they must be engaged or you will lose them to industry.
- "The adversary in an A2AD battle who can achieve the best convergence of electronic warfare and cyber warfare will dominate."
- "Planning for the A2AD battle needs a time horizon well beyond the Future Years' Defense Plan (FYDP) five year planning window. The Naval Air Warfare Center Weapons Division (NAWCWD-China Lake) seems to be looking beyond the FYDP. Many organizations working this problem are "Program Objectives Memorandum (POM)-bound"-- i.e., their planning horizons are anchored in this or next Government fiscal year(s)." The context is who is in charge of strategic planning for the organization and what is NAWCAD doing to consider its strategic role?
- "A2AD battle planners can be "joined at the hip" with both the Naval Research Laboratory (NRL) and the Air Force Research Laboratory (AFRL). NAWC Aircraft Division (NAWCAD) needs to be not only the test and evaluation (T&E) and technology transfer (T2) agent for the, it needs to lead A2AD solutions [that can be also developed at NRL/AFRL]. The Navy needs to protect aircraft carriers in the short term and devise other solutions; [like] the Air Force needs to protect aircraft bases--these protection activities are similar."
- "The A2AD battle will be fought mostly with unmanned aerial vehicles (UAVs), not F/EA-18s." The context is how is the strategic focus changing and does the organization understand a clear path to morph?
- "NAWCAD should be more engaged with U.S. Pacific Command (PACOM) and the PACOM science advisor. NAWCAD should attend PACOMs S&T conference, held each March [and for that matter conferences in general]. PACOM's science and technology (S&T) organization has experts

embedded in it from the National Laboratories (Sandia and Livermore), University Affiliated Research Center (UARCs--George Tech Research Institute), Federally-Funded Research and Development Centers (FFRDCs--the Aerospace Corporation, RAND) and other premier research and development (R&D) organizations. NAWCAD should adopt this model and allow R&D expertise from these organizations to embed." To integrate, relate and discuss is to learn and grow as an organization. The learning organization embraces collaboration.

- "NAWCAD needs to build an environment to pull relevant R&D into acquisition and T&E programs."
- "Some former NAWCAD experts who should be involved in the A2AD battle planning problem should include former NAWCAD Executive Directors, who oversaw a $100 million investment in stealth technology at Patuxent River and subject matter experts, such as the nation's expert in naval air radars." Who is looking out for critical intellectual mass to converge on solutions, and integrate their collaborations into the plans?
- "NAWCAD should forge a closer relationship with the Defense Advanced Research Projects Agency (DARPA), not as a "DARPA performer", but as DARPA's demonstration/validation, T&E and T2 agent. Does NAWCAD even know what DARPA is doing?"
- "Important in the A2AD battle will be "dispersing the target," meaning carriers, and that in A2AD scenarios it is vital to reduce the vulnerability of concentrated forces." Who is designing technical solutions to this metric?
- "The Navy should consider "prepositioning" in smaller, less costly and less vulnerable units, as seen in the need to address the offensive-defensive energy balance, that being how much energy does one need to spend on defending, for instance, concentrated forces, like a carrier battle group. What is the "fighting molecule"—i.e., what is the smallest integrated unit that can/should be moved in the "offensive-defensive energy balance"—is it the carrier? The task force? Air wings? Individual aircraft? Other? It may be a worthy goal to make this "fighting molecule" as small and cheap/easy to replace as possible." A future concept for design is "Many-Small-Fast-

Cheap" vs. "Few-Large-Slow-Expensive" which tends to dominate large acquisition programs.

- "An airplane is a "reusable booster," that delivers an expendable energy device, called a weapon. It is useful to look at different ways to label platforms and concepts, as a way to look at the problem differently." Do we need reusable boosters?
- "An important future dimension is the psychology of the warrior. The main difference between man and machine is emotional aspect, and that in addressing something like A2AD, one really needs to think about how to get an adversary to do what we want them to do. He noted the role of the human is moving from the physical, to the intellectual to the psychological." What does this mean for NAWCAD? For engineering?
- "Younger folks should get involved in addressing new paradigms for warfare and interacting with enlightened, experienced staff. Younger staff really needs to be exposed to senior leaders—indeed, perhaps turn our mentoring models upside–down by having young, technology savvy people mentoring the "graybeards."
- "If you are going to do something that is hard, and really hasn't been done before, you have to use discretionary funding to get this done. You need a combination of fiscal and human resources to get this done. Our system "trains" naval officers to act deterministically, and we "educate" civilians, to deal with our probabilistic environment. We should design both our weapons systems and our organizations around unique aspects of humans—what humans can do that machines can't." The context was also to mention that novel solutions for machines can be designed in suit.
- "Consider the scientist-engineer-military officer model, in which the scientist offers what is possible, the engineer determines what is practical, and the military officer determines what is useful. In order to get someone to solve a problem they need resources with which to experiment and make mistakes. Military organizations are necessarily deterministic—creative scientists and researchers are probabilistic, and motivated by ideation. We need young, fresh scientific thinkers higher up in the chain." In the context of budgets for experimentation, test and iteration to produce viable solutions, even from warfare centers.

- "The Navy labs were constructed to "conceive, construct and confirm," which is one of the reasons why they have unique facilities. The Navy labs need to be where concepts are experimented upon and mistakes are tolerated. Rapid technological change has made age and time-in-grade much less important. There were five domains in which the Navy needed to have centers of excellence: air, surface, subsurface, cyber and platforms." Context was things unique to naval solutions.
- "A Skunk works-like piece of the organization should be basic to NAWCAD. We need to get back to a focus on building "teams" rather than "competencies." People die for their buddies, not for their organizational hierarchies, and want to belong to something bigger than them." The context was in designing what was needed for the future of NAWCAD.
- "Industry really needs to be viewed as a true partner. New models of inclusion need to be developed. Industry is only going to be as good as the Navy in-house folks help them to be, by being really expert in what they do. There is a need for balance among industry, civilian researchers and the military with each in complimentary role —not competitive or adversarial roles."
- "There is too great a focus on ships, and particularly aircraft carriers in the US Navy, when the emphasis should be on warfighting capacity and the declining utility of manned tactical aircraft. This is a question of how power is delivered. The benign operating environment of the past two decades has lulled the leadership and masked the declining relevance of these expensive systems, meaning carriers and manned carrier aircraft. The institution of naval aviation has not been meaningfully tested in four decades, not even in 1990, when it faced no significant threat from Iraqi SAMs or aircraft." *This was set in the context that the carrier as a platform is highly vulnerable – from air, sea, sub-surface, space and cyber means. If power is linked inextricably to the carrier, and adversaries have developed the means to disable or worse (dispose of) these ships, then the ability to project power declines as this one platform declines, which would be highly disruptive to NAWCAD.*
- "There is evidence that the institutional stakeholders and leadership of the Navy and aviation communities are aware of these facts, but are striving constantly for 'sustaining innovations,' to borrow a concept from Clayton Christiansen.

They focus on the immediate, instead of the smaller and more marginal technological and other challenges that gradually eat the bottom out of their market. That's TACAIR today. It's in trouble and it is unrecognized by the institution."

- "In a dense A2AD environment, the challenges and difficulties of operating a carrier effectively multiply radically. Crucial here is not the number of sorties that the carrier can pump, but the difficulty involved in doing so as the carrier is ducking, hiding, and running, which radically limits its utility. George Friedman is useful in this connection: if the cost of defending a platform is greater than its offensive value – measured variously – then it's senile. That's TACAIR. Almost every meaningful improvement in tactical aviation over the past few decades has been defensive, as compared to the much more incremental improvements in its offensive utility."
- "There is an irreducible value of warheads delivered by missiles from great distances, as there are fewer and fewer places where manned TACAIR can go at acceptable risk. Missiles, drones, and UCAVs are not just promising, but legitimate substitutes."
- "There can be little faith in the campaign analysis process to recognize the importance of thinking speculatively against so much uncertainty [like A2AD]. The ghosts of McNamara haunt us still – e.g. 'If the elements of a decision cannot be quantified, then they are without merit.' Senior leaders are understandably risk averse, extremely so, and will be reluctant to alter established habits until the Navy is dealt a terrible defeat. The CNO in particular views the world through a risk metric, and cannot but understand every decision as a trade-off that stands to cost the fleet dearly."
- "We should stop using categorical and superlative terms like "dominance" and instead focus on disruption [and technical solutions that facilitate a commander's adaptation]. Controlling in strategic terms is a fool's errand and impossible anyway. Disruption and denial [options] cost less. The costs in strategic terms that we don't have to pay to achieve our ultimate goals are a good place to start an analysis."
- "There are three forms of warfare, heroic, systematic, and disruptive. Heroic warfare is an expression of decisive genius, requiring maneuver and excellence and brilliant execution to succeed. The U.S. defense budget is itself heroic, a reflection of

the constant demand for the absolute best all the time and in every dimension. Systematic warfare is rational and heavily organized, and overcomes to victory through sheer, dogged force. The Red Army in Europe conformed to this model. But Disruptive is the strongest of the three, and is ironically adopted only by the weakest states and actors. The purpose, of course, is less to control or project than to prevent stronger actors from doing so." The context was to posit – "how do our institutions factor this in and or use if for design constraints, particularly disruptive warfare.

- "Since 1991, the U.S. has labored under the delusion that technology and brilliant maneuver would produce rapid, decisive victories. Our efforts along these lines have pushed opponents up and down the spectrum to adopt [and adapt] regimes of disruption. It is screamingly obvious that strikes on the Chinese mainland or other key assets will be hard to justify politically and likely court a nuclear escalation."
- "War between the U.S. and China not likely or possible, but inevitable. "The Pacific isn't big enough for both powers and the U.S. is a strategic itch that the Chinese just can't scratch." The context approaches the likelihood question of A2AD warfare.
- "Carrier aviation is a heroic form of military power: its true nature was glimpsed in 1942-3 at Midway and Coral Sea and in the Solomons. The Battle of the Philippine Sea, which has been so iconic for the Navy, was deeply misleading, because the imbalance of military potential between the U.S. and Japan was grossly uneven by then, and because Spruance, an intellectually adaptive and insightful military genius, had a schedule to keep and could afford to wage a defensive battle. Halsey was a mal-adaptive brute. But the point is that the Navy over the long term has learned to love the carrier for the wrong reasons." As if to say, what are the right reasons to love the carrier today and in the future, and do they outweigh the love of other solutions in the context of A2AD?
- "GO UNMANNED. Devise escalatory options for a mixed deterrence regime, as he calls it, and give policy-makers options for handling strategically ambiguous scenarios against an opponent optimized for anti-access. NAVAIR should, must focus on long-range, high-endurance platforms with the capacity to reconstitute the ISR regime when the opponent jams it or takes it down completely. The carrier and its swarms of X-47s

must reprise their role of the 1930s and become the eyes of the fleet. NAVAIR should stand out as able to populate the battlespace with ISR."

- "Fundamental is the context in which the Ford-class is to operate. Pumping high numbers of sorties is irrelevant in the face of modern anti-access technologies and systems. Carriers cannot compete with affordable VLS systems on surface ships, or even submerged. They offer a higher rate of delivery at much lower cost. After construction of the third Ford-class, the Navy should produce heavily modified LHA/LHDs, of which they can purchase about 20 for the cost of 10 super-carriers." The context was the future and offset decisions.
- "Cost, cost, cost. The cost [of major aircraft programs] is so high that it leaves [little to] nothing for utterly crucial stand-off platforms and weapons, leading to an [unacceptably] unbalanced force. Our enemies have had our playbook for the last sixty years, have memorized it, and have their answers."
- "The Chinese have a 'thirteenth man', to work a metaphor. Pressure the carrier relentlessly and let us believe that we have informational security and dominance, when we don't. Should the value of aviation in the future [focus on] the ability to direct fire, versus deliver it? The ISR complex could be built around it, particularly if the Navy can make the rail gun work. If the target can be acquired, then the rail gun will tear it apart. Today, roughly 2/3 of the weight of a shell or missile is oxidant/propellant. The railgun round needs no oxidant or propellant, and will radically change how firepower is delivered." And perhaps even how it is stored or even manufactured at sea. How does the future of naval aviation work with other future firepower?
- "How did the U.S. respond to the echelon formation problem? The US suffers a myopia about technology. Strategies are constructed in response to them, when strategy should be guiding technology development." The context is to say who is designing strategy and based on what inputs and intellectual exchange? How are the support institutions of the Navy involved in strategic plans?
- "<u>What answers to the pressing operational problem of the access battle has naval aviation? High sortie rates with overpriced, unsurvivable aircraft</u>? Forty years of uncontested [access and]

success in a forgiving environment is no compelling argument, and it's high time in historical terms that a "thinking opponent" knocks over that house of cards. The Halsey Alpha group at the War College has worked through the problem time and again and arrived at the same conclusions." This was raised in the context of change: Who in NAVAIR, including NAWCAD is listening? What other references, wargames, and perspectives is NAWCAD considering? What tools are they using to consider these things? Where does change management come from?

APPENDIX 2:

Technology sub indicators as areas recommended for tracking for possible inclusion in the ACE Tool kit.

This is a partial list of topics chosen for most relevance to comparative assessment issues. The general categories of Business, Economics & Management, and Social Sciences and their subcategories are also available but were omitted at this time. Google also provides the h5 metric* with each sub area and the listing of the most cited papers and their individual h5 metric.

* Per Google Scholar, "h5-index is the h-index for articles published in the last 5 complete years. It is the largest number h such that h articles published in 2009-2013 have at least h citations each."

Physics & Mathematics	Engineering & Computer Science	Chemical & Material Sciences	Life Sciences & Earth Sciences	Health & Medical Sciences
Acoustics & Sound	Architecture	Analytical Chemistry	Agronomy & Crop Science	Addiction
Algebra	Artificial Intelligence	Biochemistry	Animal Husbandry	AIDS & HIV
Astronomy & Astrophysics	Automation & Control Theory	Ceramic Engineering	Atmospheric Sciences	Alternative & Traditional Medicine
Biophysics	Aviation & Aerospace Engineering	Chemical Kinetics & Catalysis	Biochemistry	Anesthesiology
Computational Mathematics	Bioinformatics &	Combustion & Propulsion	Bioinformatics &	Audiology, Speech & Language Pathology
Condensed Matter		Composite		

Physics & Semiconductors	Computational Biology	Materials Corrosion	Computational Biology	Biomedical Technology
Discrete Mathematics	Biomedical Technology	Crystallography & Structural Chemistry	Biophysics	Cardiology
Electromagnetism	Biotechnology	Dispersion Chemistry	Biotechnology	Child & Adolescent Psychology
Fluid Mechanics	Ceramic Engineering	Electrochemistry	Birds	Clinical Laboratory Science
Geometry	Civil Engineering	Inorganic Chemistry	Botany	Communicable Diseases
Geophysics	Combustion & Propulsion	Materials Engineering	Cell Biology	Critical Care
High Energy & Nuclear Physics	Computational Linguistics	Medicinal Chemistry	Developmental Biology & Embryology	Dentistry
Mathematical Analysis	Computer Graphics	Molecular Modeling	Ecology	Dermatology
Mathematical Optimization	Computer Hardware Design	Nanotechnology	Environmental & Geological Engineering	Diabetes
Mathematical Physics	Computer Networks & Wireless Communication	Oil, Petroleum & Natural Gas	Environmental Sciences	Emergency Medicine
Nonlinear Science	Computer Security & Cryptography	Organic Chemistry	Evolutionary Biology	Endocrinology
Optics & Photonics		Polymers & Plastics	Food Science &	Epidemiology
Plasma & Fusion				Gastroenterology & Hepatology
Probability &				Genetics & Genomics
				Gynecology

Statistics with Applications Pure & Applied Mathematics Quantum Mechanics Spectroscopy & Molecular Physics Thermal Sciences	Computer Vision & Pattern Recognition Computing Systems Data Mining & Analysis Databases & Information Systems Educational Technology Environmental & Geological Engineering Evolutionary Computation Food Science & Technology Fuzzy Systems Game Theory and Decision Science		Technology Forests & Forestry Geochemistry & Mineralogy Geology Hydrology & Water Resources Insects & Arthropods Marine Sciences & Fisheries Microbiology Molecular Biology Mycology Oceanography Paleontology Pest Control & Pesticides	& Obstetrics Heart & Thoracic Surgery Hematology Immunology Medical Informatics Medicinal Chemistry Molecular Biology Natural Medicines & Medicinal Plants Neurology Neurosurgery Nuclear Medicine, Radiotherapy & Molecular Imaging Nursing Nutrition Science Oncology

	Human Computer Interaction Information Theory Library & Information Science Manufacturing & Machinery Materials Engineering Mechanical Engineering Medical Informatics Metallurgy Microelectronics & Electronic Packaging Mining & Mineral Resources Molecular Modeling		Plant Pathology Proteomics, Peptides & Amino acids Soil Sciences Sustainable Energy Virology Wood Science & Technology Zoology	Ophthalmology & Optometry Oral & Maxillofacial Surgery Orthopedic Medicine & Surgery Otolaryngology Pain & Pain Management Pathology Pediatric Medicine Pharmacology & Pharmacy Physical Education & Sports Medicine Physiology Plastic & Reconstructive Surgery

	Multimedia Nanotechnology Ocean & Marine Engineering Oil, Petroleum & Natural Gas Operations Research Plasma & Fusion Power Engineering Quality & Reliability Radar, Positioning & Navigation Remote Sensing Robotics Signal Processing Software Systems			Psychiatry Psychology Pulmonology Radiology & Medical Imaging Rehabilitation Therapy Reproductive Health Rheumatology Social Psychology Surgery Toxicology Transplantation Tropical Medicine & Parasitology Urology & Nephrology Vascular Medicine Veterinary Medicine

	Structural Engineering Sustainable Energy Textile Engineering Theoretical Computer Science Transportation Water Supply & Treatment			Virology

Top 20 Aviation & Aerospace Engineering technical journals. One can than drill down even further. For one of NAWCAD's interest areas one can call up information on the sub-topic of "Aviation & Aerospace Engineering". Doing so would present lists of the top Aviation & Aerospace Engineering technical journals:

Rank	Publication	h5-index	h5-median
1.	AIAA Journal	33	46
2.	Journal of Guidance, Control, and Dynamics	31	42
3.	Journal of Turbomachinery	30	37
	Acta Astronautica		35
4.	Journal of Aircraft	29	27
	Journal of Spacecraft and Rockets	23	30
		21	25

5.	Journal of Propulsion and Power	21	25
	Aerospace Science and Technology	20	32
6.	Progress in Aerospace Sciences		25
7.	IEEE Aerospace Conference	19	24
	International Journal of Aeroacoustics		26
8.	IEEE/AIAA Digital Avionics Systems	19	21
	Conference	17	19
9.	Journal of Aerospace Engineering	16	22
	Chinese Journal of Aeronautics	16	20
10.	IEEE Aerospace and Electronic Systems	16	19
	Magazine	15	19
11.	Journal of Turbulence	15	23
	IEEE/ION Position, Location Navigation	14	20
12.	Symposium.	14	
	Proceed. Inst. Mech. Eng., G: J Aerospace	12	
13.	Eng.	12	
	Advances in the Astronautical Sciences		
14.	Navigation		
15.			
16.			
17.			
18.			
19.			
20.