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2022

The Production of Arms and Influence: Weapons, Diplomacy, and the Technopolitics of Nuclear Strategy

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Princeton, NJ : Princeton University

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THE PRODUCTION OF ARMS AND INFLUENCE:

WEAPONS, DIPLOMACY, AND THE

TECHNOPOLITICS OF

NUCLEAR STRATEGY

Leyatt Betre

A DISSERTATION

PRESENTED TO THE FACULTY

OF PRINCETON UNIVERSITY

IN CANDIDACY FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

RECOMMENDED FOR ACCEPTANCE BY

THE SCHOOL OF PUBLIC AND INTERNATIONAL AFFAIRS

Adviser: Christopher Chyba

September 2022

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ABSTRACT

This dissertation examines the historical and political-economic conditions that first gave rise to the modern U.S. nuclear arsenal and the discursive terrain common to the professional communities that oversee its modernization. As a work of both technological and intellectual history, this study traces the origins of certain widely held narratives regarding the nature and purpose of U.S. nuclear weapons by following these claims through to the political realities that first motivated their articulation. In drawing together histories of postwar science advising, weapons development, and nuclear strategy, this study locates one formation of a robust pro-research-and-development (R&D) consensus in the U.S. military within the post-World War II drive to regularize Navy support for basic research by cultivating a service-wide commitment to undersea warfare. This research further shows that the roots of this consensus trace back to the early postwar years, during which scientists empowered from their wartime collaborations with the military worked to secure a continued stream of federal research funding as well as a more lasting institutional role within the nascent U.S. nuclear weapons establishment. Their success in this endeavor was co-constitutive with the rising profile of the anti-submarine warfare (ASW) mission within the postwar Navy, and drew support from the permissive organizational context created by prevailing interservice rivalries over roles and missions. Scientists and industry representatives who stood to benefit from regularized Navy funding for R&D capable of supporting deep-water operations characterized ASW work as indispensable, with simultaneously defensive and offensive applications that reconsolidated Navy rationales for the fleet's air, surface, and subsurface forces around the domain of undersea warfare. Claiming the postwar threat from Soviet submarines would be ever-present, technical communities transformed politically loaded charges of system vulnerability into productive engines driving the pursuit of follow-on systems. This measure-countermeasure dialectic inaugurated by undersea warfare specialists prompted weapons designers to justify such follow-on developments in terms that reflected and even anticipated the evolving political consensus regarding the ideal character of the national nuclear strategy and force structure. Lastly, this research shows that the U.S. pursuit of multiple warhead technology originated out of this same process of seeking politically viable programs of countermeasure development, and that the widespread perception of these systems as counterforce weapons did not materialize until the Soviet Union began testing its own multiple warhead systems.

Introduction

For many contemporary observers, the opening of the strategic arms limitation talks (SALT) in the fall of 1969 seemed to mark a hopeful turning point in the confrontational arc of preceding decades, as nuclear diplomacy stood poised to subvert the early Cold War prognosis of an unconstrained arms race. Within three years, the first phase of strategic arms control had yielded two separate agreements -- SALT I and the Anti-Ballistic Missile Treaty -- both signed on the occasion of the May 1972 Moscow Summit by President Nixon and Secretary Brezhnev. Yet, while these accords respectively froze the number of strategic land- and sea-based ballistic missiles to existing levels and placed a cap on the number of anti-ballistic missile installations either country could deploy, many in the arms control community, including some directly involved in the negotiations, argued that these frameworks in fact failed to impose meaningful constraints on the most destabilizing features of the evolving arms race, and thus represented not landmarks but tragic missed opportunities.[1]

To understand why arms controllers in particular became so thoroughly disillusioned with the shape that the US-Soviet arms control dialogue ultimately took in the 1970s requires situating this community historically in the broader epistemic ferment taking place around contemporary issues of nuclear strategy and military technology. In the first two decades of the Cold War, a number of political scientists, economists, and mathematicians were preoccupied with determining the proper relationship between nuclear diplomacy, military doctrine, and technological development in a well-

[1] See Thomas C. Schelling, "What Went Wrong with Arms Control?" *Foreign Affairs* (New York, N.Y., 1986) 63: 219-233; Gerard C. Smith, *Double Talk: The Story of SALT I*, (Lanham, MD: University Press of America, 1985).

ordered national policy, meaning one that was guided above all by a sober, "scientific" appraisal of certain strategic novelties introduced by the atomic age. The most prominent of these considerations – that world war now carried with it the risk of civilizational extinction – to this community presented the central constraint under which bureaucrats, scientists, and elected officials needed to coordinate their efforts in order to instantiate and optimize the operation of rational deterrence.

In the view of early arms controllers, maintaining this delicate steady state solution to the Cold War problem required nurturing a so-called "balance of terror" within which neither the United States nor the Soviet Union could attack the other and escape devastating nuclear retaliation in response. The purpose of arms control, according to the academics that gave the term new life following a string of abortive 1950s-era general disarmament initiatives, was summed up by Thomas Schelling and Morton Halperin in their classic 1961 monograph, *Strategy and Arms Control*:

> We believe that arms control is a promising, but still only dimly perceived, enlargement on the scope of military strategy. It rests essentially on the recognition that our military relation with potential enemies is not one of pure conflict and opposition, but involves strong elements of mutual interest in the avoidance of a war that neither side wants, in minimizing the costs and risks of the arms competition, and in curtailing the scope and violence of war in the event it occurs.[2]

This definition, with all its tensions and ambiguities, became the de facto mandate of arms controllers both inside and out of government over the course of the next decade. Arms control experts thus came to identify and position themselves as constituent members of the professional class of nuclear strategists and a pillar of the Cold War defense establishment, as

[2] Thomas C. Schelling and Morton H. Halperin, *Strategy and Arms Control*, (New York: Twentieth Century Fund, 1961), 1.

collectively they anchored a dominant pole of the discursive terrain characterizing the nuclear policy debates of the 1960s. However, as that decade wore on, a seemingly competing pole coalesced around fundamentally different assumptions regarding nuclear strategy, and ultimately succeeded in disrupting arms controllers' established narratives not only about the sources of deterrence, but even about the proper scope and practice of arms control itself. While this alternative school of thought was by no means monolithic, it was unified in its belief that what arms controllers lauded as the bedrock of stability, mutual vulnerability, in fact presented an existential threat to deterrence.[3] As unpalatable as these views still seemed to arms controllers during the Kennedy-Johnson years, within a decade following the inauguration of the SALT process they had become axiomatic within the strategic policy establishment of the United States.

The same year that Schelling and Halperin published their canonical work on the theoretical tenets of arms control, the newly inaugurated Kennedy administration established the Arms Control and Disarmament Agency (ACDA), institutionalizing within the Executive Branch the perspective that stable deterrence – that is, what had become by the end of the 1950s the overriding objective of national security policy – depended upon "a conscious adjustment of [U.S.] military forces and policies to take account of those of our potential enemies, *in the common interest of restraining violence*."[4] In practice, for self-identified arms controllers this

[3] Lawrence Freedman, *The Evolution of Nuclear Strategy,* (London: Macmillan Press, 1983); John Garnett and John Baylis, *Makers of Nuclear Strategy,* (London: Macmillan Press, 1991).

[4] Schelling and Halperin, *Strategy and Arms Control,* 6. Emphasis added.

translated into not only accepting but codifying a condition of mutual vulnerability between the United States and the Soviet Union. The task of enacting deterrence then boiled down to securing, through novel diplomatic channels, the retaliatory capabilities of the United States and the Soviet Union.

Despite this rosy if Strangelovian theoretical picture, what the RAND analyst Albert Wohlstetter in 1958 had called "the delicate balance of terror" – which at the time of his writing had allegedly been jeopardized by what he considered precariously sloppy operational practices by the Strategic Air Command – again stood to be rudely upset over a decade later, this time by what arms controllers considered technological overreach.[5] Specifically, they argued that a series of technical innovations in the areas of warhead miniaturization, re-entry vehicle design, and guidance systems on long-range missiles promised to reignite the arms race, in spite of quantitative restrictions negotiated in the first phase of the SALT process.[6] According to arms controllers, what made these developments so destabilizing was that new weapon systems incorporating these technical breakthroughs would be sufficiently accurate and maneuverable to threaten military installations in addition to cities, and thus capable of upending the stability of the relative nuclear balance.

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[5] Albert Wohlstetter, "The Delicate Balance of Terror: Condensed from Foreign Affairs January, 1959," *Survival (London)* 1, no. 1 (1959): 8–17.

[6] Frank Marzari, "The Derangement of MIRV," *International Journal* 26, no. 4 (1971): 753–70; John Newhouse, *Cold Dawn: The Story of SALT*, (Washington: Pergamon-Brassey's, 1989); Joel S. Wit, "American SLBM: Counterforce Options and Strategic Implications," *Survival (London)* 24, no. 4 (1982): 163–74.

Furthermore, parallel shifts in nuclear targeting doctrine transformed the technical potential of these systems into apparent operational realities, as American military planners began designating Soviet missile silos and other military bases as priority targets for the use of nuclear weapons.[7] These technological and strategic innovations, here collectively referred to as the counterforce revolution, contribute yet another wrinkle to the checkered legacy of détente – that the routinization of U.S.-Soviet arms control and its formal recognition of strategic parity occurred alongside the development and deployment of weapon systems that many considered categorically antithetical to the project of arms control and its associated logic of deterrence.

A satisfactory explanation reconciling the apparent simultaneity of the advent of arms control and the counterforce revolution would require a comprehensive treatment of contemporary political, economic, strategic, and technical realities in the United States and the Soviet Union across multiple levels of analysis – most of which remains outside the scope of this study. Nevertheless, the task of formulating such an explanation must begin by understanding the terms on which each of these contemporary realities shaped the dialogue between diplomacy and weapons development. To that end, this dissertation focuses on the processes of technological change which eventually came to underpin, and lend authority to, claims about the desirability of adopting a counterforce nuclear posture.

To be sure, paying attention principally to matters of technology is not to disregard questions of politics, economics, or strategy, but rather to attend first and foremost to the

[7] Fred M. Kaplan, *The Wizards of Armageddon* (New York: Simon and Schuster, 1983).

question of how these factors dynamically managed and reshaped the constraints and opportunities faced by actors directly engaged in projects of technological development. Conversely, a focus on technology can usefully foreground the potential for processes of incremental technical change to reorder the distribution of power, resources, and preferences within and among organizations that held the most at stake in informing the long-term shape and composition of military force structure.

At present, many widely accepted narratives regarding the evolution of military technology and strategy in the nuclear age lack a comprehensive historical accounting. The result has been that ideas such as the inexorability of qualitative advancements or the identification of particular technical attributes with specific operational doctrines exist today largely unmoored from the historical conditions that first gave them credibility. This study grounds these discourses within the historical dynamics that brought about the emergence of those technologies which appeared to upend the promises of the early arms control process. In so doing, this project contributes broader insights into the role of discourse in actuating the process of weapons development in the nuclear age. Most importantly, attending to questions of this sort can reveal new sites and levers for democratic interventions into the historically siloed realm of military technology.

I: Do Armaments Have Politics?

> "In controversies about technology and society, there is no idea more provocative than the notion that technical things have political qualities. At issue is the claim that the machines, structures, and systems of modern material culture can be accurately judged not only for their contributions of efficiency and productivity, not merely for their positive and negative environmental side effects, but also for the ways in which they can embody specific forms of power and authority."[8]
>
> –Langdon Winner, 1980

> "Everybody thinks that there was a lot of push behind these missiles, and there wasn't. People in the Navy [were] pushing, but nobody outside of the Navy gave a damn...about a ballistic missile at sea that I ever heard of."[9]
>
> —Arleigh Burke, 1972

Introduction

On August 12, 1960, the long-serving Chief of Naval Operations Admiral Arleigh Burke paid an unexpected visit to the civilian wing of the Navy Department. Burke's message to his civilian counterpart, service secretary William B. Franke, boded ill for the organization they jointly managed: that is, in the eyes of the CNO, the Air Force had just pulled off a coup. After having provided Franke a debrief of the previous day's meeting at the White House, where Burke had attempted to hold the line against Air Force Chief of Staff General Thomas White's effort to centralize the military's nuclear target planning under the Strategic Air Command (SAC), Burke lamented what he considered the dire

[8] Langdon Winner, "Do Artifacts Have Politics?," *Daedalus (Cambridge, Mass.)* 109, no. 1 (1980): 121.

[9] Admiral Arleigh Burke, interview by John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 19 September 1972, 6.

implications of his failure to dissuade President Eisenhower and Secretary of Defense Thomas Gates from going along with the Air Force proposal.

> Tom [General White] will do everything he can of course – he has got to drown me. He has got to drown me. But I will fight like hell in or out of the Service. I realize it is completely ineffective outside. That thing has got to be good because if SAC gets control of this thing, the number of atomic weapons will be tremendous and they will be the wrong kind of atomic weapons. The numbers of forces will be tremendous. There will be thousands and thousands of Minutemen. They will control the budget. They will control everything, and they will wreck – I am sure they will wreck everything in the rest of it if they can. And the Joint Chiefs of Staff and the Secretary of Defense and nobody else can stop it because they are the ones that have it figured. And they are the only ones who have the figures. In a year of this stuff – you can never undig it. Grave harm. And the President won't have the guts any more than the past Presidents have had the guts – because these people will then be entrenched. The systems will be laid. The grooves will be dug. And the power will be there because the money will be there. The electronic industry and all of those things. We will wreck this country.[10]

Burke would go on to explain that he "was told to keep it quiet and [was] violating that" in telling the Navy Secretary what had transpired at the meeting with the president, but that he did so in order to prepare Franke in the event that the admiral chose to tender his resignation, in protest of SAC's growing control over the national nuclear war plan. The timing of this as-yet tightly-contained controversy was potentially explosive, as the 1960 presidential race had by August just kicked into high gear. The surprise Democratic nominee, the young senator from Massachusetts John F. Kennedy, had emerged from the previous month's convention deeply critical of the Eisenhower administration's military policies, particularly in the domain of strategic weapons. The following months saw Kennedy

[10] Admiral Burke's Conversation with Secretary Franke, 12 Aug 1960, Top Secret, Washington Navy Yard, Operational Archives, Arleigh Burke Papers, SIOP/NSTL Briefing Folder, 8.

steadily chip away at his opponent's lead, as the Republican nominee and incumbent Vice President Richard M. Nixon struggled to defend the administration's record on matters of national security.

At the same time, SAC personnel were hard at work on a proof of concept for the Air Force plan that had been set in motion at that August meeting at the White House.[11] By the end of the year, a nominally joint task force of SAC, Navy, and Army officers had produced a draft operational plan for the wartime use of the nation's existing stock of nuclear weapons.[12] The plan, which quickly obtained the signatures of Secretary Gates and President Eisenhower in view of the approaching turnover of administrations, raised alarms throughout the officer ranks of the Navy for the resemblance it bore to Burke's bleak prophecy. The Strategic Integrated Operational Plan, or SIOP-62, aimed over 3,200 nuclear weapons at 1,060 targets across the Soviet Union, China, and Warsaw Pact countries.[13] The implications of the SIOP's institutionalization of "overkill" for the subsequent evolution of U.S. military planning are difficult to overstate. In defining the parameters that would characterize a coordinated nuclear strike by the United States, the SIOP set in place operational requirements that seemed to create a permanent hierarchy among the future plans and programs of each service.

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[11] This proof of concept was what Burke had referred to as "that thing" during his meeting with Secretary Franke.

[12] The Joint Strategic Target Planning Staff consisted mostly of SAC personnel, who numbered 219 in total, compared to 28 naval officers and 10 army representatives. See David Alan Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," *International Security* 7, no. 4 (1983): 3–71.

[13] William Burr, "U.S. War Plans Would Kill an Estimated 108 Million Soviets, 104 Million Chinese, and 2.6 Million Poles: More Evidence on SIOP-62 and the Origins of Overkill," *UNREDACTED* (blog), November 8, 2011, https://unredacted.com/2011/11/08/u-s-war-plans-would-kill-an-estimated-108-million-soviets-104-million-chinese-and-2-3-million-poles-more-evidence-on-siop-62-and-the-origins-of-overkill/.

Nuclear historians have long pointed to the contentious inter-service struggle which produced the SIOP as the formative, defining acid test that confirmed once and for all the primacy of SAC doctrine within the nuclear planning arms of the defense establishment.[14] The organizational victory that the formal adoption of the SIOP represented for the Air Force – that is, in the plan's endorsement of Air Force planning principles, organized around large-scale attacks on urban-industrial and military targets – has served to focus much of the subsequent scholarship on strategic and technological developments within that particular service, often at the expense of contemporary developments within the other military branches and non-uniformed segments of the nuclear establishment.[15] The picture that we are left with from the historiography of U.S. strategic weapons development thus positions the Air Force squarely in the foreground, as the central driver of national policy on issues relating to the conceptualization and production of next-generation weapons systems throughout the Cold War.

However, Burke's confidential warning to his service secretary invites us to examine more closely the implications of a historiographical fixation on the Air Force that has gone hand in hand with a tendency to truncate analysis of actors outside of that organization – even when such actors constituted some of the Air Force's most significant interlocutors. Most notably in this regard, the U.S. Navy has been subject to far fewer scholarly treatments regarding its role in the evolution of

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[14] See Rosenbrg, "Origins of Overkill."

[15] See Edmund Beard, *Developing the ICBM: A Study in Bureaucratic Politics*, Institute of War and Peace Studies (New York: Columbia University Press, 1976); John M. Curatola, *Bigger Bombs for a Brighter Tomorrow: The Strategic Air Command and American War Plans at the Dawn of the Atomic Age, 1945-1950* (Jefferson: McFarland & Company, Incorporated Publishers, 2015); Ted Greenwood, *Making the MIRV: A Study of Defense Decision Making* (Cambridge, Mass: Ballinger Pub. Co, 1975); Edward Kaplan, *To Kill Nations: American Strategy in the Air-Atomic Age and the Rise of Mutually Assured Destruction* (Ithaca, [New York]□; London, [England]: Cornell University Press, 2015).

national policies on strategic weapons development and nuclear doctrine.[16] Most existing Navy-centric studies emphasize the development of the Polaris submarine-launched ballistic missile (SLBM) system, first deployed during the fall of 1960, as marking the beginning of the Navy's effective engagement on matters of national-level nuclear strategy. The timing of the Polaris deployment and the SIOP controversy – both taking place over the same span of months – in fact points to a much longer history of Navy efforts to advance a strategic and technological agenda that in the early postwar years ran dramatically counter to that of the Air Force.

Fragments of this story have been told in various settings, in different levels of detail.[17] What remains missing is an understanding of what exactly Burke meant – and more importantly, why he meant it – when he predicted that following the Air Force's lead would commit the country to building "*the wrong kind* of atomic weapons."[18] Scholars of nuclear history are by now familiar with the Cold War debate over "how much is enough," throughout which military and civilian policymakers espousing competing ideologies of force planning battled for control over the size and composition of the growing U.S. nuclear arsenal.[19]

Less well-understood, however, are the ways in which this debate has taken for granted the qualitative dimensions of the various force structures that the defense establishment was continually

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[16] See Richard G. Hewlett and Francis Duncan, *Nuclear Navy, 1946-1962* (Chicago: University of Chicago Press, 1974); Harvey M. Sapolsky, *Polaris System Development* (Cambridge: Harvard University Press, 1971); Graham Spinardi, *From Polaris to Trident: The Development of US Fleet Ballistic Missile Technology* (Cambridge University Press, 1994).

[17] There is the relatively well-known thread concerning the so-called "revolt of the admirals," in which Navy leaders took an early stand against the direction of postwar U.S. military strategy. See Jeffrey G. Barlow, *Revolt of the Admirals: The Fight for Naval Aviation, 1945-1950* (Washington, DC: Brassey's, 1998).

[18] Emphasis added.

[19] Alain C. Enthoven, *How Much Is Enough? Shaping the Defense Program, 1961-1969*, [1st ed.] (New York: Harper & Row, 1971).

assessing, most visibly on the narrow basis of sufficiency. In other words, while the existence of differing standards and methods of determining sufficiency in weapons requirements has become a well-documented finding of the academic literature on nuclear history, the historical origins of such frameworks have been far less closely interrogated, especially in the context of contemporary technological developments.[20]

This dissertation begins from a recognition that the metrics by which institutions judge the feasibility, desirability, and indeed, sufficiency of proposed policies often originate within the process of developing exactly those policies upon which such metrics are expected to render independent judgments. That is, the standards that come to dominate the terms of any policy debate are never neutral; in fact, they most frequently emerge from the same contested sites of activity and the same sets of participants whose work forms the primary object of evaluation.[21] This tendency toward the internalization of the evaluative function finds perhaps its fullest expression in the opaque, hyper-specialized realm of nuclear weapons policy. The technical communities responsible for designing and developing nuclear weapons and their associated air-, land-, and sea-based platforms indeed played a critical role in determining the very "requirements" that formalized the existing political demand for these systems.

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[20] For notable exceptions, see Donald A. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, Inside Technology (Cambridge, Mass.: MIT Press, 1990); Rebecca Slayton, *Arguments That Count: Physics, Computing, and Missile Defense, 1949-2012*, Inside Technology (Cambridge, Massachusetts: MIT Press, IEEE Xplore, 2013).

[21] For a contemporary example of this dynamic within the context of the fossil fuel industry and climate change policy, see Michael E. Mann, *The New Climate War: The Fight to Take Back Our Planet* (Brunswick, Victoria: Scribe Publications, 2021).

At the same time, these communities operated within evolving institutional contexts which acted to structure the incentives, risks, and opportunities available to actors seeking to enact a particular technopolitical agenda. Burke's fears of a SAC-dominated war planning process reflected not only the anticipated loss of Navy autonomy within the nuclear target planning apparatus, but also the likelihood of further encroachments on current and future Navy programs under the post-1960 dispensation. The adoption of the SIOP appeared to leave service leaders with no choice but to attempt to reconcile their disparate planning assumptions in the process of jointly formulating the national nuclear target list, in stark contrast to the decentralized arrangement that had prevailed within the military branches prior to 1960. Nevertheless, this new framework did not prevent actors within the Navy or their collaborators in industry and academia from pursuing their own programmatic objectives, even as it did, as Burke put it, materially "entrench" the interests of SAC officials in the formulation of the SIOP itself.

Put differently, the story of how the post-1960 evolution of the U.S. nuclear weapons establishment proceeded to enact (and in important ways, to subvert) Burke's prophecy is a story of how Navy-sponsored figures and the professional communities to which they belonged ultimately helped to reshape what key audiences thought were "the wrong kind of atomic weapons." In tracing that story, this dissertation follows the work of naval strategic weapons research and development from World War II through the first two and a half decades of the Cold War. Throughout this period, the technical communities that were engaged in this line of work learned to legitimize claims about what constituted the right or wrong kind of weapons by appealing to the operational and doctrinal logics that animated contemporary debates within the ranks of their military patrons. The associations

they forged between certain types of technologies and particular strategic postures survive today in the normative assumptions that continue to underpin the discourse of nuclear weapons policy in the United States.

This dissertation reexamines this history by taking seriously the contention, common to science and technology studies, that such discursive frames reveal more about the framers themselves than the objects they mean to describe. Understanding the communities and processes responsible for producing these frames is key to unlocking the political content contained within such ways of conceptualizing nuclear weapons and their implications for world politics. In this chapter, I discuss the long-standing assumptions, disciplinary norms, and professional boundaries which have constrained present-day understandings of when and where certain ubiquitous nuclear narratives first emerged. To paraphrase an important recent work of scholarship on the social history of arms control, this dissertation seeks to recover the historical and political contexts which first gave form and credibility to official claims of the strategic consequences that would attend the development of various nuclear weapons systems.[22]

To begin this task, this chapter provides a critical overview and synthesis of existing scholarship from a wide range of disciplinary traditions, all of which raise questions of central importance to this study. Such an overview will serve to situate this study within the broad areas of scholarship that have historically addressed questions of nuclear weapons development as well as the types of institutional processes and professional communities involved therein. As this dissertation

[22] See Benjamin Tyler Wilson, "Insiders and Outsiders: Nuclear Arms Control Experts in Cold War America" (Ph.D., United States -- Massachusetts, Massachusetts Institute of Technology), accessed July 25, 2022.

takes up the question of what role such processes and communities played in the production of nuclear narratives that have since become foundational to the present-day study of nuclear strategy, this dissertation is necessarily an interdisciplinary undertaking. Moreover, the recognition that such narratives are indeed *produced* compels us to examine the politics of the R&D process itself. Where security studies treatments of nuclear weapons often look to the deployment of these systems outward to their putative effects on international politics, this study instead looks in the opposite direction, toward the technical communities which first secured and sustained the necessary political support to bring their weapons concepts through to fruition.

In the following section, I lay out the research questions at the center of this study, along with the empirical bounds that demarcate the time frame and institutional contexts explored here. Next, I discuss the assumptions, claims, and key insights of past scholarship in security studies, science and technology studies, and histories of science and technology. I conclude this chapter by outlining the theoretical and methodological interventions of this research and presenting an overview of the dissertation's overall structure. The role of this chapter is thus to serve as an anchor for navigating the empirical and analytical terrain presented in this study. Given the relative scarcity of interdisciplinary treatments of nuclear weapons related topics, this following offers a means of drawing out and reconciling the tensions inherent in a syncretic approach to answering the questions outlined below.

Research Questions

This dissertation examines the historical and political-economic conditions that first gave rise to the modern U.S. nuclear arsenal and the discursive terrain common to the professional communities that oversee its modernization. As a work of both technological and intellectual history, this study traces the origins of certain widely held narratives regarding the nature and purpose of U.S. nuclear weapons by following these claims through to the political realities that first motivated their articulation. More specifically, this dissertation explores the historical processes of technological change that came to underpin – and lend authority to – claims about the desirability of the United States adopting a counterforce nuclear posture by the early 1970s.

This chapter contextualizes the theoretical and methodological interventions of the dissertation by grounding it within the material and intellectual history of the military research and development (R&D) complex that emerged alongside the U.S. nuclear weapons establishment during the first thirty years following the end of World War II. This discussion highlights the analytical affordances and limitations of existing research that together offer the starting point for this dissertation's historical treatment of Navy-sponsored strategic weapons R&D in the areas of undersea warfare and long-range ballistic missiles. This chapter further clarifies the logic of attending to the first half of the Cold War by marking the historical junctures which acted to open and subsequently to close debate about the strategic implications of emerging capabilities in anti-submarine warfare (ASW) and missile payload design. In turn, this chapter justifies the methodological choice of focusing on

these two substantive areas of early postwar naval R&D by highlighting their role in defining the political stakes of pursuing certain technological and doctrinal agendas within the shifting contemporary context of the Navy and the wider national military establishment.

To be sure, paying attention principally to matters of technology is not to disregard questions of politics, economics, or strategy, but rather to attend first and foremost to the question of how these factors dynamically managed and reshaped the constraints and opportunities faced by actors directly engaged in projects of technological development. Conversely, a focus on technology can usefully foreground the potential for processes of incremental technical change to reorder the distribution of power, resources, and preferences within and among organizations as well as the wider base of technical communities engaged in weapons development and long-term force-planning.

I now lay out the key questions that animate this study, and explain their import for the problems raised above:

What processes informed the designation of certain weapons systems as being "counterforce" in nature, and what implications did this designation come to carry over time?

Another way of asking this question is: what, politically speaking, is in a name? Who *gets* to name R&D programs (in a doctrinal sense) that grow out of dynamic institutional contexts where political and organizational interests are always in flux? Presently, a number of widely accepted narratives regarding the evolution of military technology and strategy in the nuclear age lack a comprehensive historical accounting, and the notion that certain weapons systems (such

as multiple warhead missiles) are inherently counterforce, and that other systems (such as the nuclear-powered missile submarine) are inherently not, is no exception. The result has been that ideas such as the inexorability of qualitative advancements or the identification of particular technical attributes with specific operational doctrines exist today largely unmoored from the historical conditions that first gave them credibility.

This question thus seeks to uncover the historical conditions which allowed for the emergence and stabilization of the technologies that eventually came to define the widely publicized U.S. pivot to a counterforce nuclear posture in the early 1970s. Answering this question is especially instructive for the purpose of informing broader inquiries into the dynamics of weapons development in the nuclear age, as the strategic rationalization of such developments constitutes a crucial and often overlooked feature of the military R&D process.

Once applied, how durable – and how significant – did the counterforce label prove in the various contexts in which such programs were proposed, attacked, defended, and judged?

This question approaches the problem of narrative consistency as an empirical one. It asks how "sticky" the counterforce label proved once affixed to a given program, weapon system, or area of research. Notably, this dynamic view of narrative associations allows for the examination of language itself as a site of contestation. In tandem with the previous question, which asks *who* and *what* was involved in affixing said labels, this question adds the important dimension of time to this study's examination of the naming process. Searching for variation over time in the strategic narratives scientists, military officers, civilian administrators, and congress members assigned to a given

technological system or potentiality further opens up the space for examining what conflicts arose in the course of getting any particular strategic label to stick. Relatedly, understanding the contextual significance of these assignations for the actors who were applying them is key to determining their political content. In other words, searching for variations over space, or the differences between how actors characterize a given weapons program in one setting versus another, offers important clues regarding the contextual specificity of these portrayals' political implications for a given program of R&D.

How did debates about what was technologically and strategically desirable get resolved, and how did the closure of these debates reflect and reshape the preferences, perceptions, and relative power positions of actors within and among organizations engaged in long-term force planning in the United States?

This final question draws our attention to the political causes and consequences of these debates over which systems to build and what to name them. Put differently, such debates do not take place in a vacuum, and the contextual specificity that defines each instance in which a strategic claim is put forward demands that the analyst take account of who made that claim, under what conditions, and in response to what audience. That changes in these contextual factors often accompanied changes in the types of claims advanced regarding a particular weapons system indicates that a systematic historical examination of these debates is necessary to understand the political content of a given strategic label.

Methodology

The empirical focus of this dissertation centers around the U.S. Navy from World War II to the end of the 1960s. Foregrounding the role that Navy programs played in defining the strategic characters of various kinds of nuclear weapons systems may strike a scholar of nuclear history as an odd methodological choice. However, this decision stems from the historical fact that many of the areas of R&D that came to be dubbed counterforce-enabling found their earliest support within the Navy. Indeed, the earliest deployed multiple warhead system was the Navy's Polaris A3 submarine-launched ballistic missile (SLBM).

Some of the earliest technological initiatives of the postwar Navy were pushed ahead by specialists of undersea warfare focused on developing more advanced anti-submarine platforms aimed at the destruction of rival military forces. Furthermore, R&D work in the realm of undersea warfare constituted one of the leading factors driving the Navy's pursuit of its own array of nuclear weapons systems and delivery platforms. Thus, these efforts represent prime sites of investigation for a study concerned with how contemporaries classified such technologies in the context of ongoing debates about the military means and ends of future war, which pitted the Air Force's strategic bombing of enemy cities against the Navy's traditional policy of targeting enemy military forces. For reasons that are explored in depth in this dissertation, the Navy's early postwar focus on the problem of engaging enemy naval forces at sea meant that

many of the technical capabilities that came to underpin the popular imagination of a counterforce weapon began under Navy sponsorship.[23]

The period spanning from the end of World War II through the beginning of U.S.-Soviet arms control talks in 1969 was a time frame in which technical communities — here defined as the scientists, engineers, planners, and administrators responsible for the definition, management, and implementation of programs of military research and development — exerted the most direct influence on the wider military establishment's perceptions of various types of nuclear weapons and their strategic consequences. Following this work through the first postwar decades offers key insights into the structuring role of military R&D in more visible contemporary debates over military strategy and doctrine. From the formative impact of the World War II experience on Navy attitudes toward what constituted an appropriate target, to the controversies of the arms control era in which politicians and diplomats came to grapple with the very same questions, a historical examination of these critical decades yields significant insights into the origins of nuclear narratives that defined much of the subsequent discourse on nuclear weapons and arms control. Centering the work of scientists and officers involved in naval R&D during this period thus allows us to home in on a set of actors whose participation in contemporary strategic debates has been systematically overlooked in the academic literature, even as their technical achievements have since been well-documented.

[23] Gary E. Weir, *Forged in War: The Naval-Industrial Complex and American Submarine Construction, 1940-1961* (Washington: Naval Historical Center, Dept. of the Navy: For sale by U.S. G.P.O., Supt. of Docs., Mail Stop: SSOP, 1993).

As a work of historical analysis, this dissertation reconstructs the professional networks, institutional contexts, and political realities that defined the historical setting described above, as well as the ways in which each of these formations mutually shaped and reshaped each other in the course of this work. The source base for this research consists of a large body of archival documents, over 1500 of which were collected over the span of two years from the Library of Congress in Washington, DC and the National Archives in College Park, Maryland. The institutional collections of Harvard University and the Massachusetts Institute of Technology also provided hundreds of pages of documents from the personal papers of key scientists and administrators central to this study. Finally, the large online databases of newspapers, as well as the transcripts of open and declassified congressional testimonies available through ProQuest have been invaluable resources that have contributed depth and nuance to this study's examination of the contemporary events, milestones, and broad political currents that reflected and affected the work of technical communities within the U.S. military establishment.

It is important to clarify what this study does not do as well as the limitations of its methodology for answering the questions posed above. This dissertation does not principally seek to explain why or how the U.S. nuclear weapons community developed the particular weapons systems that it did. Rather, this dissertation interrogates the role that these developments played in informing perceptions of what the strategic consequences of such weapons would be in the minds of policymakers and the wider public. This distinction is key to understanding why this project foregrounds technical communities rather than those who have more traditionally been considered "decision-makers" by security studies scholars.

Indeed, the space of actors that are politically engaged in the work of weapons development extends far beyond the familiar figures that comprise the uppermost echelons of the military branches, the Pentagon, or the White House. The scientists and engineers from industry and academia that were active in the sphere of military R&D during this time period navigated this space guided by their own assessments of the risks, incentives, and opportunities posed by their participation. As a result, the nature of that participation is necessarily of a political character that demands historical scrutiny. The principal limitations of this study relate then to the fact of its constrained empirical focus on largely Navy-sponsored technical communities. In reality, many of the scientists and industry personnel belonging to these networks were simultaneously involved in projects or advisory bodies bearing Navy, Air Force, and Army designations. It is thus likely that there existed certain interactions and internal pressures resulting from these cross-cutting institutional obligations beyond those captured in this study. Nevertheless, this project's focus on the work of the technical communities behind Navy programs in anti-submarine warfare and submarine-launched ballistic missiles offers important insights into the material and political linkages connecting these two areas of R&D to more visible debates regarding the appropriate goals of arms control and other forms of strategic policy.

Historiographical Overview and Interventions

The Cold War security studies literature has registered a range of competing views as to how the United States and the Soviet Union, typically constructed as a pair of rational, unitary actors

operating from a particular set of assumptions regarding the present state and projected evolution of the relative nuclear balance, could cooperatively effect and maintain a condition of "strategic stability." The crux of the debate centered around two main poles, corresponding to the two dominant frameworks that organized academic and official pronouncements on nuclear strategy during the Cold War: the familiar "mutually assured destruction" (or "countervalue") posture which targeted an adversary's cities with survivable second-strike nuclear forces in order to hold at risk the adversary's society, and the more controversial "war-fighting" (or "counterforce") strategy which targeted an adversary's nuclear forces with highly accurate, flexibly employable weapons designed to limit damage from a retaliatory strike, in order to hold at risk the adversary's deterrent capability.[24]

Both of these opposing frameworks were presented by their advocates as solutions to the problem of maintaining strategic stability amid the flux of an ongoing arms race. Where they diverged was in their precise characterization of the threat that arms racing posed for stability – those who favored countervalue targeting located this threat in the potential for arms competition to produce new types of weapons systems capable of holding at risk an adversary's strategic forces, while those favoring counterforce argued that it was precisely the inevitability that such weapons would be developed which necessitated the adoption of a war-fighting strategy. Both of these frameworks understood arms control to be a vehicle for managing the arms race, and both often pointed to the autonomous march of technology as being the root cause of the latter, though they came to widely differing conclusions on the question of how arms control was to intervene in this risk-generating process in the interests of stability.

During the 1960s and 1970s, mainstream opinion among arms control experts regarded the central objective of arms control to be cementing a state of mutual vulnerability – a condition

[24] Lawrence Freedman, *The Evolution of Nuclear Strategy*, 3rd ed. (New York: Palgrave Macmillan, 2003).

synonymous with the definition of strategic stability espoused by proponents of countervalue targeting doctrine – and its primary means to be the cooperative management of technological developments that they deemed destabilizing. Counterforce advocates, on the other hand, regarded arms control to be stabilizing only insofar as it limited the other side's counterforce capability, which was the only type of counterforce they deemed destabilizing. In other words, both camps diagnosed the arms race as being a product of the very nature of technological development in the nuclear age – it was in their prescriptions for how arms control could be applied to remedy this dynamic that they diverged so dramatically and with such lasting consequences. By the time U.S. declaratory policy formally shifted to a predominantly counterforce posture in 1980, the strategic weapons systems then deployed had already over the course of the preceding decade been advertised – and maligned – as counterforce systems. Moreover, recent scholarship has suggested that the degree to which, at least in the United States, counterforce thinking successfully eclipsed other modes of organizing nuclear strategy and force structure has thus far been underappreciated.[25]

Nevertheless, particularly in the fields of international relations and security studies, scholarly treatments of the Cold War nuclear arms race, and the successive diplomatic efforts made to constrain it, have largely black-boxed processes of technological change in ways that, at best, portray weapon systems and treaties as essentially the vector outcomes of bureaucratic forces, or more often as non-interacting barometers or determinants of U.S.-Soviet relations throughout this period.[26] The difficulties and shortcomings in this line of reasoning are several, and are worth laying out here.

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[25] Austin Long and Brendan Rittenhouse Green, "Stalking the Secure Second Strike: Intelligence, Counterforce, and Nuclear Strategy," *Journal of Strategic Studies* 38, no. 1–2 (2015): 38–73; Niccolò Petrelli and Giordana Pulcini, "Nuclear Superiority in the Age of Parity: US Planning, Intelligence Analysis, Weapons Innovation and the Search for a Qualitative Edge 1969-1976," *International History Review* 40, no. 5 (2018): 1191–1209.

[26] Edmund Beard, *Developing the ICBM: A Study in Bureaucratic Politics*, Institute of War and Peace Studies (New York: Columbia University Press, 1976); Raymond L. Garthoff, *Detente and Confrontation: American-Soviet Relations from Nixon to Reagan*, Rev. ed. (Washington, D.C: Brookings Institution, 1994); Francis J Gavin, *Nuclear Statecraft: History*

First, analyses that fix organizational interests ex ante fail to account for the inherent uncertainty involved in projects of technological development, and thus neglect the fluidity with which changes in the design and projected capabilities of emerging systems can reshape and reorder the perceptions and priorities of institutional actors. Second, rendering interests uniform at the organizational level imposes an artificial and premature closure on live, internal debates regarding expectations about technological possibilities, as well as which of those possibilities should be considered desirable and which should be avoided altogether. In the context of the Cold War nuclear arms race, the traditional dominance of bureaucratic and realist political explanations has meant that only the winning arguments from these debates have been assessed as evidence in accounting for the empirical record of how the US-Soviet arms competition ultimately developed, leaving unexplained the formative processes that prevented individuals from identifying and selecting alternative paths.

Third, organizational frames often do not take a full inventory of the interests held by the constitutive members of the organizations they foreground analytically. For example, there is a common refrain in case studies of weapons development which holds that military organizations created for the purposes of R&D are innately programmed to advocate for follow-on next-generation systems. However, the Special Projects Office of the US Navy, responsible for designing and developing all generations of the SLBM force, actively (though in the end, unsuccessfully) resisted efforts by the Office of the Chief of Naval Operations to force improvements in accuracy beyond the capabilities of deployed second-generation Poseidon missiles. The reasons for SPO's reluctance to build a successor system to the Poseidon are twofold: for one, top project officials considered the current type Poseidon sufficiently accurate for fulfilling the traditional task of the

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and Strategy in America's Atomic Age (Cornell University Press, 2012); Ted Greenwood, *Making the MIRV: A Study of Defense Decision Making* (Cambridge, Mass: Ballinger Pub. Co, 1975).

sea-based leg of the nuclear triad (namely, second-strike retaliation against cities); moreover, the prospect of provoking a turf war with the Air Force over ultra-accurate missile systems reinforced the lack of enthusiasm within SPO for pursuing a highly accurate counterforce weapon. In short, organizations are often forced to make tradeoffs among countervailing objectives and priorities as well as reconcile these considerations with more deeply rooted commitments, such as those concerning institutional identity and mission.

Finally, bureaucratic politics explanations suffer from frequent and stylized invocations of techno-deterministic assumptions. The practice of conceptualizing technological artifacts, and the technical communities that design and build them, as exogenous variables continually manufacturing new strategic realities and imposing them on the wider world, while an obsolete perspective for modern scholars of science and technology studies, is alive and well in parts of political science, international relations, and security studies. A notable exception to this rule is Matthew Evangelista's comparative assessment of the dynamics of military innovation in the United States and the Soviet Union, which argues that the interaction between the differing organizational personalities and political economies of the American and Soviet defense establishments provides a better explanation for the observed character of the arms race than the standard action-reaction or bureaucratic politics models. Evangelista argues that in the United States a bottom-up process of "technological entrepreneurship" explained its tendency to pursue high-risk projects of qualitative modernization, while in the Soviet Union the demand for extreme secrecy resulted in a highly centralized and compartmentalized top-down model of weapons development that emphasized replicating and mass-producing American advances.[27]

[27] Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies /* (Ithaca□:, 1988).

While Evangelista's contribution productively breaks down the oversimplified binaries that had structured previous political science treatments of arms racing, it erects certain new ones in their place by invoking broadly oppositional characterizations of the environments surrounding American and Soviet weapon designers, likely to be at least in part an artifact of his source base, which draws heavily on the memoirs of Russian émigré scientists in order to reconstruct the Soviet experience. Moreover, despite his case study being the development and deployment of tactical nuclear weapons in the 1970s, Evangelista's consideration of arms control is surprisingly limited, confined essentially to the observation that attempts to secure symmetric concessions in this forum were wrong-headed and should have instead sought out bargains that traded American technological restraint in exchange for Soviet quantitative restrictions.

In addition to works of political science and international relations theory, historical studies of the Cold War provide a necessary contextualization for the sites and processes of interest to the study proposed here. Over the past few decades, historians have located the nexus of contemporary science and technology, politics, and society in a diverse array of national, local, organizational, and biographical contexts. The canonical accounts in this literature speak to the social, political, and institutional ecology of Cold War era scientific research.[28] In his study of the development of the laser and the field of nonlinear optics, Paul Forman advanced the controversial argument that physics, and indeed the natural sciences more broadly, in this time period become wholly-owned subsidiaries of the Cold War military program of weapons-focused research and development. In *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford*, Stuart Leslie provides further ammunition for the Forman thesis by tracing the proliferating and deepening

[28] Paul Forman, *Behind Quantum Electronics: National Security as Basis for Physical Research in the US, 1940-1960*, *Behind Quantum Electronics□: National Security as Basis for Physical Research in the US, 1940-1960*, 1987.; Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia University Press, 1993).

linkages among government, industry, and academe that over time took root in the frenzied postwar R&D landscape of competitive universities and businesses scrambling to attract lucrative military contracts. The unique institutional trinity captured by Leslie's "military-industrial-academic complex" provides a broadly encompassing framework in which to situate the individuals, projects, and discursive practices that will be the subject of the dissertation proposed here.

Some of the most path-breaking contributions to our understanding of the diverse processes giving rise and shape to state-sponsored Cold War era projects of technological development have come from multidisciplinary works that draw on a rich assortment of methodological and empirical strategies from a range of social science traditions. Important works in this mold have included historical sociologies of the evolution of missile guidance systems and the broader co-production of scientific knowledge and authority.[29] In *Inventing Accuracy*, Donald MacKenzie convincingly dispatches the conventional wisdom offered by technological determinism on the trajectory of the Cold War arms race – which attributes improvements in missile accuracy to the unrelenting march of technology toward ever more capable systems – by demonstrating that whatever was meant by "improvements," "more capable systems," or even "accuracy" was itself fashioned, and continually reconfigured, in the flux of competing institutional, cultural, and political interests. Crucially, MacKenzie focuses not on the elected decision-makers who were the nominal directors of this process but the entrepreneurial scientists, bureaucrats, and military officers directly engaged in the day-to-day brick-laying of missile accuracy's social construction over the course of the Cold War. [30]

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[29] Sheila Jasanoff, *States of Knowledge: The Co-Production of Science and the Social Order*, International Library of Sociology (Abingdon, Oxon: Routledge, 2004); Rebecca Slayton, *Arguments That Count: Physics, Computing, and Missile Defense, 1949-2012*, Inside Technology (Cambridge, Massachusetts, Piscataqay, New Jersey]: MIT Press, IEEE Xplore, 2013).

[30] Donald A. MacKenzie, *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*, Inside Technology (Cambridge, Mass.: MIT Press, 1990).

In turn, Sheila Jasanoff and Rebecca Slayton have both shone a light on the role played by expert advisors at underexamined sites of national sense-making and policy-making. In particular, their analyses foreground the ways in which expertise, as a resource, has appeared not only adjacent to but also in forms constitutive of political power. Jasanoff's study of the practice of science-advising in the lower echelons of federal and state government addresses an important gap in the contemporary scholarship – a product of scholars' historical tendency to engage only with the effect of expert advice on presidential decision-making – and in the process makes clear the ubiquitousness and frequently contested status of technocratic interventions in the evaluative and regulatory functions of the state.[31] Slayton provides yet another illuminating corrective on a literature already rich in empirical findings relevant to the study proposed here. Specifically, in her account of expert advising in the setting of US missile defense priorities in the post-World War II era, Slayton asks: how do elite scientists and engineers craft politically persuasive arguments about technological futures, and why do certain arguments hold sway over others? Her answer takes readers through a revealing comparative assessment of the differing "disciplinary repertoires" used by physicists and software engineers to inform and shape expectations of missile defense possibilities in the minds of top decision-makers. By tracking how these expert communities generated policy-relevant technical advice and navigated the competitive marketplace of ideas influencing official attitudes toward missile defense, Slayton fruitfully demonstrates the explanatory leverage scholars gain by examining the process rather than simply the output of expert advising by politically salient technical communities.

In yet another disciplinary vein, innovative work by anthropologist Hugh Gusterson illuminates the cultural processes that have given the "ideology of nuclear deterrence" its formidable

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[31] Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers*, First Harvard University Press paperback edition. (Cambridge, Mass. u.a: Harvard Univ, 1994).

staying power, emerging in no small part part due to the collectively shared lived experiences of the individuals responsible for stewarding national nuclear capabilities, that serve to instantiate and reproduce an authoritative faith in the reliability of these systems to keep the peace. Gusterson's revealing ethnographies of American weapon scientists demonstrate the utility of keeping in mind certain analytical insights from the field of anthropology, perhaps the discipline most far-flung from the spaces where scholars have traditionally taken up questions of nuclear strategy and military technology. The "exoticizing gaze" of the anthropologist can indeed help bring into focus the processes and practices whereby groups of nuclear strategists, like weaponeers and anti-nuclear activists, "have arrived at different but deeply held convictions about nuclear weapons."[32]

In sum, by situating this project at the intersection of security studies and the history of technology, I suggest that these disparate fields can and should be placed in closer, more productive conversation than has traditionally been the case. Political science and security studies scholarship would be well served by pursuing such a cross-disciplinary research agenda attuned to the encompassing, mediating, and recursive social factors that would afford this discipline much-needed purchase on questions it has always considered to be of lasting importance. Similarly, scholars of science and technology studies stand to benefit from a closer engagement with topics that have long been the de facto remit of the more positivist social sciences. As this study endeavors to make clear, these subjects remain ripe for examination using the critical tools furnished by sociologically informed conceptualizations of technology.

[32] Hugh Gusterson, *Nuclear Rites: A Weapons Laboratory at the End of the Cold War* (Berkeley: University of California Press, 1996), 4.

Chapter Structure

The following is an overview of the dissertation's main body chapters, which progress in a roughly chronological sequence from the World War II period to the end of the 1960s. As each chapter follows the work of actors engaged in the development of a particular class of weapons system and their resulting investments in associated lines of R&D, there remains some degree of overlap in the time frames explored in each chapter.

Chapter 2 begins by charting the development of the professional communities that furnish the dissertation's key individual actors, whose work I then trace throughout the period from 1940 to 1972. These include the civilian ocean scientists whose research gained a massive if at times fickle patron in the U.S. Navy, the small but ascendant group of naval officers preoccupied with the challenges and opportunities they saw in the future of undersea warfare, and the industry personnel whose determined pursuit of commercial atomic energy production centralized within the private sector the technical expertise and resource base necessary for the pursuit of both civilian and military nuclear applications. In explaining the ways in which each of these groups of actors came to regard work on naval reactors, advanced submarines, and anti-submarine warfare as supportive of their respective long-term agendas, this chapter sets up much of the relevant historical context for the subsequent program-oriented chapters.

Chapter 3 explains how the interdependence which grew up between and among these communities contributed to the development of the first ballistic-missile-carrying-submarine and its associated weapon system — the Polaris missile. By following the simultaneous efforts of

Polaris program officials to define, sell, and build this system, I deepen and extend the preceding chapter's account of the symbiotic relationship that developed between the various R&D communities engaged in advanced submarine design and anti-submarine warfare.

Chapter 4 examines the relationship between Navy-sponsored work on submarines and the U.S. drive to develop MIRVs, or multiple independently-targetable reentry vehicles, over the course of the 1960s. Arguably the most controversial technological development of the nuclear age, MIRVs have since acquired a strategic reputation that remains at odds with that of its earliest portrayals by the technical communities which first designed this system. This chapter thus interrogates the circumstances under which early postwar naval R&D in the areas of warhead miniaturization, solid fuel propellants, and guidance and navigation systems attracted interest and subsequently competition from other quarters of the national military establishment, principally by demonstrating the political advantages of maintaining malleable representations of MIRV-relevant programs on Capitol Hill.

The conclusion of this dissertation places in broad historical perspective the structuring effects of strategic weapons R&D on contemporary understandings of the appropriate goals, scope, and mechanisms of arms control. I then further draw out the contributions of this study to existing scholarship in security studies and the history of science and technology. Finally, the conclusion ends with a brief reflection on what these findings indicate regarding the profound structural limitations of the arms control process as it has historically been practiced for the task of checking the overall pace of weapons development.

II: The Problem(s) of Overseas Transport: Undersea Warfare and the Targets of Postwar Naval Interest

"The introduction of atomic power has given new importance to seapower…Our defense priorities are no longer our own coast lines…Today our frontiers are the entire world."
--Admiral Chester W. Nimitz, 1945

"The results of the [Nautilus] tests so far conducted definitely indicate that a complete re-evaluation of submarine and antisubmarine strategy will be required. Its ultimate impact on Navy warfare should not be underestimated."
--Captain Eugene P. Wilkinson, 1955

Introduction

By late July 1949, U.S. Navy pilots like Commander Alfred B. Metsger were beginning to see themselves as something of an endangered species. Then serving in the Pacific Fleet, Metsger had taken on an infinitely more fraught assignment that summer as an assistant to the task force responsible for defending the Navy's overall service concept ahead of its most public trial to date. Following allegations publicized earlier that spring of financial impropriety in the Air Force's procurement of the B-36 bomber – Strategic Air Command's (SAC) latest long-range nuclear delivery platform – the House Armed Services Committee announced that it would hold back-to-back hearings, first to investigate the allegations, and second to evaluate competing Air Force and Navy visions for their respective service roles and the wider national military strategy. Like many of his fellow aviators, Metsger feared that naval air power would soon succumb to a death by a thousand cuts absent major interventions on (and from) Capitol Hill. In turn, Navy leaders regarded the slated hearings as possibly the last opportunity to salvage an independent role for naval aviation in the developing national

atomic air strategy. Despite the clear stakes involved, Metsger anticipated that top Navy officials would fold under political pressure emanating from the Pentagon and the Navy's own civilian leadership. In a July 26 briefing to his commanding officer, Admiral Arthur Radford, Metsger framed the implications of the approaching congressional debate in the following terms:

> Crisis. Air Force and other officers have us on the ropes...
> Surface Navy abandoning us, salvaging all possible.
> Top policy has abandoned air as a primary naval weapon, is emphasizing ASW [anti-submarine warfare]. No continuing defense of Naval Air visible...
> Naval Aviation at present rate will be finally licked with the '51 budget.[33]

For Radford, himself an aviator and a former Vice Chief of Naval Operations, Metsger's briefing only corroborated a long growing sense that the fight with the Air Force would "probably mean all or nothing in the long run" for the viability of the naval air mission.[34] While the congressional hearings that stretched across the late summer and fall of that year were by no means the first public confrontations between the Navy and its youngest sibling service, the hearings did present the most high-profile opportunity to date for officers seeking to contest what many in the Navy considered a disturbing contemporary trend in defense planning: the increasing centrality of strategic bombing and atomic weapons to the national military establishment's vision of future war. At issue was not only the matter of the Navy's recently-canceled supercarrier program and the insistence of aggrieved naval aviators that the Air Force's B-36 was entering service obsolete, but in addition the question of whose

[33] Jeffrey G. Barlow, *Revolt of the Admirals: The Fight for Naval Aviation, 1945-1950* (Washington, DC: Brassey's, 1998), 225.
[34] Ibid., 225.

goals, definitions, and standards would be permitted to dominate the terms of the national debate over military strategy.

To the surprise of many in their own service, top Navy officers did rally to the defense of naval aviation in their testimony before congress, effecting a dramatic break from the party line established by civilian officials in the Navy department as well as the office of the secretary of defense (OSD). In what contemporary press accounts termed "the revolt of the admirals," several high-ranking Navy figures, all the way up to the sitting Chief of Naval Operations, Admiral Louis E. Denfeld, argued that the loss of strategic naval air assets capable of carrying out precision strikes against inland military installations would place U.S. national military policy on a dangerous footing going into the age of atomic weaponry.

According to Denfeld, Radford, and others, the strategic bombing concepts propounded by the Air Force threatened to divorce military strategy from the fulfillment of any conceivable national objective. Leading off the first day of Navy testimony on October 6, Radford cautioned: "The type of war we plan to fight must fit the kind of peace we want. We cannot look to the military victory alone, with no thought to the solution of the staggering problems that would be generated by the death and destruction of an atom blitz."[35] Taking an altogether different approach, Radford went on to criticize the B-36 technical grounds as "unacceptably vulnerable" and incapable of the type of precision bombing that would enable strikes on military targets, the only class of targets he considered practically and morally defensible for war planners in the atomic era.

[35] Testimony of ADM Arthur W. Radford, House Armed Services Committee, *Unification and Strategy: Hearings*, 41.

Beyond the media spectacle of the hearings themselves, the political aftermath of the admirals' revolt made a lasting impression on a generation of mid-career Navy officers who saw their superiors roundly disciplined for their public criticism of prevailing air atomic strategy. Among the career casualties was the Chief of Naval Operations himself, Admiral Denfeld, who within weeks of his testimony was fired by Navy Secretary Francis Matthews. A then-Captain Arleigh Burke nearly lost his previously all-but-assured promotion to the ranks of the admiralty on account of his work as the head of the much-maligned Op-23 division in the office of the CNO – the Navy's clearinghouse for summary and analysis of developments relevant to Navy interests, and in press accounts described as the Navy's in-house public relations and opposition research firm.[36] In the wake of this highly publicized setback, the Navy was left far from unified within its own ranks as to what lessons it should take from this episode for the long-term viability of its traditional air and surface platforms.

While the admirals' revolt trained the political spotlight on the strategic role of naval aviation and the surface forces needed to support that mission, the preceding decade had seen a growing consensus develop out of a cobbled-together network of officers, scientists, and industry contractors, which identified the future of the postwar Navy most closely with the domain of *undersea* warfare, as well as, notably, the development of sea-based atomic weapons. Contemporary coverage and subsequent historical accounts of the admirals' revolt largely leave out the degree to which the Navy's

[36] Contemporary press accounts lambasted Burke in particular as running "a secret publicity bureau almost solely dedicated to smearing the Army and Air Force and disrupting unification." See, for example, Drew Pearson, "Admirals Running Handout Mill," *The Washington Post (1923-1954); Washington, D.C.*, October 19, 1949, sec. LOCAL NEWS Classified Advertising. Notably, Pearson was himself a controversial figure whose reportage often sensationalized or blatantly misrepresented the facts of political events. For further reading, see Donald A. Ritchie, *The Columnist: Leaks, Lies, and Libel in Drew Pearson's Washington*, (New York: Oxford University Press, 2021).

service identity and the viability of its existing force structure in the atomic age were still being actively contested within the officer ranks of the organization at the end of the 1940s. These internal debates reflected both the shifting institutional terrains of postwar military planning as well as the ways these changes dovetailed with competing imaginations of the lessons of World War II for naval operations.

Central to these imaginations were the disparate experiences of the Pacific and Atlantic Fleets in their wartime operations against the Japanese and German navies, the former having been typified by an amphibious war of attrition heavily dependent on carrier-based aircraft, and the latter by the technological and operational challenge of hunting the submersible U-boat for the protection of Allied forces and transatlantic shipping lanes. The specificity of the strategic and tactical objectives facing naval personnel in each of these complex theaters spawned an array of operational viewpoints going into the postwar period on issues ranging from the role of submarine and anti-submarine warfare (ASW) in maritime strategy to the prospects facing shipborne deployment of atomic weapons. On each of these questions, throughout World War II and the years immediately following, stark internal disagreements gave way to the appearance of service-wide consensus only by virtue of the political pressure-cooker presented by contemporary parallel trends of rising inter-service and geopolitical conflict.

This chapter examines the evolution of intra-Navy debates concerning what over the course of the first decade following World War II came to be known in key circles as the problem of overseas transport. The task of overseas transport, as it was characterized by participants of the 1950 Hartwell Project summer study, emerged as a useful shorthand for both combat and peacetime operations deemed relevant to the protection of commercial shipping as well as the protection of the Navy's

surface fleet.[37] The importance of tracing "the problem of overseas transport" as an organizing node of postwar naval planning stems from the historical fact of its capaciousness as an operational goal – one that would prove capable of justifying virtually the entire spectrum of naval platforms and weapons systems. By tracking the course of early postwar research and development (R&D) efforts in nuclear technology, advanced submarine design, and ASW, this chapter describes the ways in which individuals engaged in these programs shaped doctrinal debates and built political support within the Navy around their conception of the ideal composition and strategic character of the postwar fleet.

In focusing on developments by and large internal to the Navy, I argue in this chapter that traditional frameworks of organizational politics have tended to overstate the role of interservice rivalry in fueling the diversification of nuclear weapons systems throughout the first half of the Cold War.[38] During this period, what one finds by increasing the resolution of the analysis beyond the scale of the organization is a more subtle and dynamic picture of weapons development than any that the standard juxtaposition between competing service interests would suggest. As much as it has served to point out genuine fault lines that have historically structured the defense policy-making process, the well-worn lens of interservice rivalry can also work to eclipse important controversies and

[37] The concept for the study that would soon become known as Project Hartwell, a joint initiative of the Massachusetts Institute of Technology and the Office of Naval Research, first came out of a January 23, 1950 proposal by Gaylord P. Harnwell of the National Research Council's Committee on Undersea Warfare. A physicist whose wartime career had been spent directing the University of California Division of War Research on behalf of the U.S. Navy Radio and Sound Laboratory in San Diego, Harnwell became a central figure in subsequent postwar efforts by civilian scientists to sustain and strengthen the community's ties to naval sponsors during peacetime. "A Report on Security of Overseas Transport: Volume I" (Massachusetts Institute of Technology, September 21, 1950): ii.

[38] Melvin Kranzberg, "Science, Technology, and Warfare: Action, Reaction, and Interaction in the Post-World War II Era," in Monte D. Wright and Lawrence J. Paszek (eds.), *Science, Technology, and Warfare,* (Washington, D.C.: Office of Air Force History, 1971).

accommodations that played out *within* organizations or communities traditionally treated as monoliths.

Attending to the debates that are often black-boxed by organizational politics accounts is necessary not only for the sake of historical accuracy, but also for revealing critical insights regarding how policy directives found themselves interpreted in the course of their implementation. In the case of weapons development, this attention must extend to the ways in which organizational directives found themselves built into, or in certain cases even preempted by, the physical systems to which they lent nominal sanction. Uncovering the true bases of material support for these systems thus demands one look further than top-down pronouncements of "military requirements," themselves the product of an existing, politically actuated organizational demand.

In this sense, I regard interservice rivalry as an important but nevertheless insufficient background condition rather than as an explanatory framework capable of illuminating the evolution of postwar naval planning in the late 1940s and early 1950s. In organizing this chapter almost exclusively around the work of Navy officers and their collaborators in industry and academia, I demonstrate that high-profile confrontations between the services such as that showcased in the admirals' revolt obscured more than they illuminated in terms of contemporary controversies regarding service roles and missions. Furthermore, I argue that such public confrontations provided a permissive context for individuals seeking to regain and regularize Navy support for basic research relevant to the domain of undersea warfare, which had indeed waned in the immediate postwar period.

The task of drawing together the various threads of this story begins during World War II in the European theater, where during the spring of 1945 advancing Allied forces discovered

experimental German U-boat prototypes that were faster, stealthier, and deeper-diving than any ship in the Allied fleet.[39] Through the design, development, and testing of the world's first nuclear-powered submarine *USS Nautilus,* launched in 1955, the mission profile of the U.S. submarine force expanded from coastal defense and shallow water operations to the peacetime protection of commercial sea lanes and the whole of the surface fleet through the use of state-of-the-art techniques and instrumentation designed for ASW. These dramatic developments occurred in the context of live debates over the Navy's strategic role as well as the proper extent of the service's technological and doctrinal commitments in the atomic age. Proponents of the undersea warfare mission found themselves helped by twin trends of rising geopolitical and interservice conflict, and from their varied posts across academia, government, and industry acted to establish certain R&D channels – particularly those concerned with the detection and management of underwater sound – as foundational to the future security and viability of the postwar Navy.

The centrality of civilian R&D to the story of postwar naval force planning and the Navy's entry into the field of nuclear weaponry demands careful attention to what I will refer to as the technopolitical affordances offered by certain types (and characterizations) of weapons systems for particular segments of the uniformed and civilian Navy. Technopolitical affordances can be understood as the benefits conferred by a given way of framing the functions and capabilities of a technological system vis-à-vis a specific audience. For example, this chapter will show that early postwar claims characterizing submarines as simultaneously defensive and offensive platforms

[39] Gary E. Weir, *Forged in War: The Naval-Industrial Complex and American Submarine Construction, 1940-1961* (Washington: Naval Historical Center, Dept. of the Navy, 1993): 73–78.

provided a durable rationale for maintaining large investments in both advanced submarine design as well as ASW. Advocates of both of these (functionally antagonistic) mission specialties leveraged the submarine platform's liminal status as its own countermeasure to generate and sustain congressional support for both categories of R&D spending. I argue that the hard-fought measure of financial and bureaucratic longevity that advocates secured on behalf of these programs constituted one technopolitical affordance of their frequently contradictory claims regarding these systems' supposed strengths and vulnerabilities.

While I make greater use of this analytic category in later chapters, which explore the development of specific technological systems in more detail, I introduce the concept of a technopolitical affordance here to emphasize its applicability to technologies that remain largely notional, as indeed many of the systems discussed in this chapter were during much of the time period captured here. Importantly, I do not use the idea to refer to artifacts themselves, but rather to the ways in which discursive renderings of these objects conferred material advantages on actors who strove to affix a particular narrative frame onto a particular technical system. Such an analytic category offers a means of tracking the production of power and preference that takes place alongside processes of technological production.

I now provide a brief overview of the sections that follow. First, I begin by describing the World War II era work of civilian scientists and submarine officers seeking to carve out a dedicated place for ocean science within the Navy's regular processes for formulating material requirements, battle plans, and operational procedures. Culminating in the reports made by the Naval Technical Mission in Europe during the last six months of World War II — focusing on the group's discovery of

experimental German U-boat prototypes while embedded within (and at times venturing ahead of) the advancing Allied front — this section situates the Technical Mission's findings within ongoing contemporary naval debates regarding the merits of submarines as offensive platforms, and discusses how perceptions of the Type XXI U-boat's novel design within the U.S. submarine community reconfigured those debates such that traditional opposition gave way to a concerted program of wartime R&D investment in advanced submarines and ASW.

Next, I trace how the demobilization of wartime industry and associated lines of Navy-sponsored R&D prompted efforts by both civilian scientists and a select group of uniformed officers to reestablish official funding channels linking the rapidly growing ocean sciences to the Navy's own growing interest in undersea warfare. This section provides an account of how the results of wartime naval research seeded the imaginations and ambitions of scientists, industrialists, and pro-submarine and ASW advocates in their drive to institutionalize undersea warfare as a domain of strategic interest for the wider Navy. This account will further show how these individuals combined a set of overlapping agendas to salvage and eventually fortify the scientific and productive capacities of the naval-industrial complex through the early postwar ebb in defense spending.

In the third section, I examine the various circumstances which allowed for the resumption of significant sustained Navy support for research geared toward solving the operational problems of undersea warfare. To this end, I begin by placing this policy pivot within the contemporary context of unification – the postwar federal initiative to reorganize the War and Navy Departments under a single National Military Establishment headed by a Secretary of Defense – and describing the succession of political setbacks experienced by Navy leaders in the years leading up to and immediately

following unification's formal adoption with the 1947 passage of the National Security Act. I then explain how the strong opposition of the Army and the newly established U.S. Air Force to carrier-based naval aviation empowered proponents of undersea warfare – initially a minority within the officer ranks of the Navy – to advance an alternative vision for the future of naval strategy and force structure. This group's ultimate success in revising their service's official policy on subsurface operations had enormous ramifications for postwar U.S. military strategy, as their plans not only incorporated but centered "the applications of atomic energy" to the purposes of pro-submarine and anti-submarine operations.

The fourth and final section then addresses directly the technopolitical maneuverings of civilian and Navy scientists in their responses to early postwar efforts to make reality the prospect of nuclear propulsion aboard submarines and surface vessels. I discuss the significance of these initiatives for contemporary work on advanced submarine design and ASW, particularly related to the task of minimizing "self-noise" generation in future submarines. The goal of this section is to explain the ways in which the nascent nuclear Navy became, at times reluctantly, imbricated in parallel lines of ASW R&D, which were themselves premised upon assumptions that located the targetability of future ships in the noise they produced in the ocean environment.

Through an examination of scientific and operational approaches to the challenge of controlling major sources of submarine self-noise, this section takes the development of the hydrodynamic "teardrop" hull of the *USS Albacore* as an instructive window on the scale and intricacy of Navy initiatives to combat noise generation in its own high-speed advanced submarine designs, an ambitious experimental undertaking which foreshadowed the development of the world's

first nuclear-powered submarine, *USS Nautilus*. The at times uneasy modus vivendi struck between advocates of nuclear propulsion and those focused on developing quieter, faster, deeper-diving submarines offers a preview of what constitutes the empirical focus of subsequent chapters, namely, the intra-organizational dispensations which positioned ASW partisans as some of the strongest and most powerful proponents in favor of developing the first submarine-launched ballistic missile.

World War II and the Type XXI

Prior to World War II, little existed of what would eventually come to be called the naval-industrial complex.[40] On the contrary, relations between the Navy and private industry had survived the First World War barely intact, and the ensuing years of the Depression served to further estrange the two communities from any sense of the other's immediate priorities. This mutual suspicion – born of wartime contracts whose fruits disappointed both the public and the private partner – lasted through the late interwar period. Even then, the large-scale increase in naval and commercial shipbuilding that turbo-charged the New Deal works programs also featured strict caps on the profit margins private firms were allowed to retain from their work on government contracts – measures that congress put in place in 1934 to prevent the sort of flagrant profiteering by the defense industry which had prompted so much popular backlash in the wake of World War I.[41]

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[40] For the most comprehensive historical treatment of "the naval-industrial complex," see Weir, *Forged in War.*

[41] The Vinson-Trammel Act of 1934 placed a cap of 10% on private profits stemming from government defense contracts, and required that every other ship slated for construction be built at a government shipyard. In its regulation of private defense contractors, the act anticipated the 1935-36 Nye Commission hearings on Capitol Hill, whose findings largely vindicated allegations of widespread profiteering among arms builders during World War I. For further background on the

The onset of the Second World War was by no means quick to erase the memories of the first half of the twentieth century, particularly for industrialists unwilling to reverse decades of financial readjustment toward commercial markets all for the sake of what they saw as destined to become yet another short-term war economy. While Navy leaders lobbied congress to carve out legal exemptions from profit caps and labor protections for private shipbuilders in a bid to attract more corporate investment in the planned naval buildup, Navy officials in turn found themselves being courted by representatives of an altogether different set of private institutions, namely those engaged in the young field of civilian oceanography.

Since 1923, Navy support for civilian ocean science had amounted to little more than a poorly funded public relations effort to recuperate the Navy's badly damaged post-World-War-I image – "by demonstrating that it could help feed Americans in peace as well as destroy an enemy in war."[42] With as yet no readily apparent military justification for undertaking deep ocean studies, these informal, ad hoc collaborations between civilian scientists and a handful of Navy officers were billed as a public good offered by the Navy toward the advancement of commercial drilling and fishing interests. Unsurprisingly, this arrangement often grated on the nerves of line officers periodically charged with

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history of naval buildups prior to World War II, see Weir, *Forged in War*, chapter 1; George T. Davies, *A Navy Second To None: The Development of Modern American Naval Policy.* (New York: Harcourt, Brace, and Co., 1940), chapter 14.

[42] The Hayes Memorandum of 1923 formalized the U.S. Navy's policy of supporting scientific research relevant to peacetime commercial interests. Named after its author and principal advocate, Swarthmore-trained physicist Harvey C. Hayes, the memorandum represented more of a wish list of the Naval Research Laboratory's underwater sound group, which Hayes himself led, than a firm service commitment to strengthening ties to civilian ocean science. Though its namesake had intended also to provide a basis for support of militarily relevant applications of ocean science, the Hayes Memorandum lacked sufficient support within the Navy to amount to much more than an inconsistently-funded PR initiative. Notably, during this time private research institutions made up the lion's share of the funding shortfall left by insufficient Navy appropriations for joint oceanographic expeditions. Gary E. Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment*, 1st ed., Texas A & M University Military History Series 72 (College Station: Texas A&M University Press, 2001), 21-99.

hosting academic researchers whose interest in naval vessels typically extended only so far as their capacity to serve as seagoing laboratories.[43]

If it appeared to be a contradiction in terms that the vast majority of Navy officers at this time saw no military application to knowledge of the deep ocean environment, it need only be clarified that the interwar U.S. Navy (and, to a large extent, the World War II era fleet) operated almost exclusively in the uppermost 300 feet of ocean.[44] With the introduction of the diesel-electric propulsion system, contemporary submarines were capable of making limited dives under electric power, though were forced to surface frequently to recharge their batteries using air-breathing diesel engines. These design features appeared to render depths of greater than 300 feet for all practical purposes irrelevant to naval operations. Moreover, prevailing naval doctrine had held since the turn of the century that the primary tactical objective of a submarine force was the defense of surface convoys and coastal targets.[45] In light of these standing assumptions, few officers outside of the Naval Research Laboratory (NRL) saw much to be gained from deepening the service's ties with university-based scientists.

Notably, however, military officers were not the only — or even the primary — figures to exercise some degree of control over such decisions in the years leading up to the U.S. entry into World War II. With the establishment of the National Defense Research Committee (NDRC) in June 1940, civilian scientists took the lead in defining, coordinating, and implementing the R&D agendas that

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[43] Weir, *An Ocean in Common*, 104. For further reading on the history of tensions between naval and scientific priorities in the realm of deep sea exploration, see Helen Rozwadowski, *Fathoming the Ocean: The Discovery and Exploration of the Deep Sea*, (Cambridge, MA: Harvard University Press, 2009).

[44] John Doughty Alden, *The Fleet Submarine in the U.S. Navy: A Design and Construction History* (Annapolis, Md.: Naval Institute Press, 1979).

[45] Gary E. Weir, *Forged in War: The Naval-Industrial Complex and American Submarine Construction, 1940-1961* (Washington: Naval Historical Center, Dept. of the Navy, 1993), 4.

would yield the next generation of military weapons.[46] Those who sat on the NDRC were among the most preeminent and well-connected members of the American scientific community, including Vannevar Bush, President of the Carnegie Institution; James B. Conant, President of Harvard University; and Frank B. Jewett, President of Bell Telephone Laboratories and of the National Academy of Sciences. Widely understood (and ultimately acknowledged) to be an "end-run" by civilian scientists around the executive policy establishment, the NDRC architecture quickly proved to be an effective and efficient conduit for channeling federal funding toward areas of R&D that had never previously attracted sustained government support.[47]

One of the domains of basic research that would be most transformed by the wartime experience was the nascent field of oceanography.[48] As a small community whose work had relied largely on the support of private foundations prior to the outbreak of World War II, oceanography was uniquely positioned vis-à-vis the new powers that be in charge of administering state funding for militarily relevant R&D. Columbus O'Donnell Iselin, who in 1940 became director of the Woods Hole Oceanographic Institution (WHOI), began his tenure as director with a clear mission: to establish oceanography, and Woods Hole in particular, as an indispensable resource to the federal government on all matters related to naval planning.[49] He was helped in this regard by his close

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[46] Irvin Stewart, *Organizing Scientific Research for War; the Administrative History of the Office of Scientific Research and Development* (Boston, Little, Brown, 1948).

[47] Vannevar Bush, *Pieces of the Action* (New York: Morrow, 1970).

[48] For further reading on the impact of postwar Navy funding on the field of oceanography, see Naomi Oreskes, *Science on a Mission: How Military Funding Shaped What We Do and Don't Know about the Ocean,* (Chicago: University of Chicago Press, 2021); See also Jacob Darwin Hamblin, *Oceanographers and the Cold War: Disciples of Marine Science*, (Seattle: University of Washington Press, 2005).

[49] Prior to becoming director of Woods Hole in 1940, Iselin had propped open the door to large-scale collaborations with the Navy when in 1937 he identified the so-called "afternoon effect" – that is, changes in the velocity of underwater sound

association with NDRC member Frank Jewett, whose summer home in Martha's Vineyard was a short sailboat trip across the sound from Iselin's full-time residence — a commute Iselin would make more days than not over the summer of 1940.[50]

In the course of their discussions, Iselin succeeded in turning Jewett into a true believer in the latent military applications of oceanographic research. In so doing, he won the field, and his own institution, a powerful ally within the NDRC. On August 5, 1940, Iselin repackaged his summer's worth of ad hoc advice to Jewett into a formal memo addressed to NDRC chairman Vannevar Bush, in which he offered the services of WHOI personnel and facilities as part of a bid to become the U.S. Navy's main private partner in devising and implementing a comprehensive program of wartime R&D. Not content to rely on Jewett's assurances alone, Iselin followed up this offer with a late August visit to NRL, during which he presented his views on the prospects for large-scale collaborations between the Navy and private institutions. By September, Iselin had officially secured a $100,000 NDRC contract for Woods Hole to study the propagation of underwater sound.[51]

From these auspicious beginnings civilian scientists continued to advocate for the elaboration of a long-term research agenda on all scientific and technical aspects of the undersea warfare mission. One aspect in particular — the continual demand for more data — worked in their favor.[52] And one

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caused by the warming of the upper layers of the ocean column at midday – as the reason behind the *USS Semmes'* paradoxically high miss rate during target practice exercises conducted in Guantanamo Bay. Solving this conundrum at the request of the *Semmes'* puzzled commanding officer positioned Iselin to make his wartime case for increased Navy support for basic research relating to the effects of the ocean environment on the propagation of underwater sound.

[50] Gary E. Weir, *An Ocean in Common:American Naval Officers, Scientists, and the Ocean Environment*, 1st ed., Texas A & M University Military History Series 72 (College Station: Texas A&M University Press, 2001), 109–11.

[51] Weir, 108.

[52] Due to the sheer variety of sound sources present in the ocean, the task of interpreting underwater acoustic signatures requires the maintenance of extensive databases of background measurements to isolate and distinguish target signals from

gadget of particular significance to the data collection effort, the bathythermograph, charted the way for ocean scientists and naval officers seeking to expand the Navy's knowledge and utilization of the deep ocean environment. Designed by Allyn Vine and others at Woods Hole, the bathythermograph (BT) was a device capable of recording the temperature profile of the ocean at variable depth.[53] Having demonstrated the implications of rapid temperature changes in the ocean column for stealth in submarine operations, BT designers lobbied successfully for the widespread use of a submarine-borne BT (and its shipboard variant) by Navy crews on patrol. [54]

In this task they had the considerable help of Jewett and his NDRC colleague, John Tate, then serving as chairman of the committee's Sub-Surface Warfare panel known as Division 6. The year leading up to the U.S. entry into World War II saw a number of civilian-led initiatives to explore and exploit the full spectrum of military applications seen as arising from a systematic study of the ocean environment. Less than two months after Iselin secured WHOI its $100,000 NDRC contract, Navy Secretary Frank Knox and NRL chief Harold Bowen established an ASW and submarine detection subcommittee under the chairmanship of Edwin H. Colpitts, a former VP of Bell Telephone Laboratories.[55]

By January 1941, the Colpitts group had published its report criticizing the Navy for failing to make optimal use of the scientific and technological resources available to the organization in its

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the surrounding ocean environment. Further baseline measurements must be taken to determine the characteristic noise profile of specific types of operationally relevant sound sources, for example, to distinguish Allied from enemy naval vessels.

[53] Weir, *Forged in War*, 50.

[54] Weir, *An Ocean in Common*, 130–32.

[55] Ibid., 111.

subsurface operations and weapons systems. Redressing this gap according to the report required that the Navy embark on a comprehensive program of R&D in acoustic, magnetic, radio, and microwave devices to supplement existing sound equipment. The Colpitts study argued that such improvements in instrumentation would be necessary to determine with sufficient accuracy the characteristic sound signatures from various types of ships under as many environmental conditions as possible, for the purposes of improving design techniques for silencing *and* detection.[56] Most importantly, the report strongly urged the Navy to study the "sound propogating [sic] properties of oceanic waters over the entire frequency range likely to be involved in the use of detecting devices," a technical feat which would require sponsoring investigations into the effects of temperature variations, salinity, convection, density, sound scattering, attenuation, and reverberation on the transmission of underwater sound.

The sheer scope and pace of proposed Navy undertakings advanced by the Colpitts report produced a marked backlash within even the parts of the service most amenable to the task of supporting basic research. Rear Admiral Harold Bowen, himself head of the Navy's premier research agency, staunchly opposed the agenda laid out by the Colpitts group on the basis that its recommendations failed to consider the operational needs and priorities of the Navy as a whole. While Bowen's concerns were ultimately overruled by Jewett, Tate, and the weight of civilian scientific authority within the NDRC administrative framework, his widely shared misgivings did prompt some civilian advisors to point out that discretion might be the better part of valor in the brewing dispute

[56] This emphasis on the potential for R&D to stimulate breakthroughs in both underwater stealth and targeting would become increasingly central to the elaboration of the Navy's scientific and technological agenda in the postwar period. For the duration of World War II, however, official interest within the service remained entirely on the perceived offensive applications of oceanographic research.

over the relative share of civilian versus military input in wartime R&D planning. Detecting no small such fear over jurisdictions in Bowen's opposition to the Colpitts agenda, Jerome C. Hunsaker – a graduate of the Naval Academy and the first head of the Department of Aeronautical Engineering at MIT – convinced Secretary Knox to revise his General Order 150 of December 1, 1941 in favor of placing a Navy officer, as opposed to a civilian, in charge of the Office of the Coordinator of R&D (OCRD). On December 13, six days after the Japanese attack at Pearl Harbor, Rear Admiral Julius A. Furer began work as the first head of OCRD.[57]

Despite this seeming concession, 1941 was a year in which civilian scientists moved to consolidate their position of authority within the growing federal apparatus overseeing wartime science, most notably with the establishment that summer of the Office of Scientific Research and Development (OSRD). In what was later described by the organization's first director Vannevar Bush as an "end run" around the executive policy establishment, OSRD effectively placed an additional layer of bureaucratic insulation between the core civilian planning committees and the military liaisons charged with monitoring federal R&D policy on behalf of the services.[58] Thus sidelined, top uniformed Navy officials exercised little to no veto power over the rash of research contracts OSRD negotiated with ocean scientists on both coasts, most notably those based at Woods Hole, the Scripps Institution in San Diego, and the University of California Division of War Research. The centralization of decision-making powers on matters of wartime military R&D in the hands of

[57] Weir, *An Ocean in Common*. 119.

[58] Richard G. Hewlett and Francis Duncan, *Nuclear Navy, 1946-1962* (Chicago: University of Chicago Press, 1974), 20.

civilians enabled the pursuit of niche and even relatively unpopular scientific initiatives by those interested in expanding the realm of possibility for naval operations in the deep ocean environment.

With the firm backing of OSRD, WHOI personnel significantly ramped up their efforts at incorporating the bathythermograph into the day-to-day operations of the Navy over the course of 1941 and 1942.[59] The accumulation of BT readings by Navy ships and submarines not only helped to build a three-dimensional temperature map of the world's oceans, but also served to track the increasing degree of practical contact between ocean scientists and line officers in wartime naval operations.[60] The newfound working relationship between these two distinct professional communities put civilian oceanographers aboard ships and subs on active patrol to perform needed measurements, and in turn required enlisted personnel to learn the rudiments of acoustical physics to facilitate on-the-spot interpretation of BT readings. This level of detailed exposure to the demands facing military personnel in their routine operations led Woods Hole scientists Maurice Ewing and Allyn Vine to develop graphical modes of representing BT data which were specially tailored for use by submarine crews on combat duty.

Ewing and Vine used BT data to plot what they called isoballast lines – that is, lines that corresponded to changes in depth and temperature which, taken together, canceled out the change in hull compression experienced by a diving or ascending sub, thus obviating the need for the crew to take in or expel ballast to maintain buoyancy. As the mechanical process by which a vessel's ballast was

[59] In a letter dated October 15, 1941, Commander of U.S.Submarine Forces Atlantic Rear Admiral Richard S. Edwards requested that Woods Hole adapt its initial ship-borne design for use by submarines. See Weir, *An Ocean in Common*, 137.

[60] Woods Hole held regular BT training sessions for naval officers preparing to serve as BT interpreters.

adjusted generated a definite sound signature, isoballast lines offered crews a means of determining by rapid inspection opportunities to dive silently to safer depths by exploiting the local temperature variations of the ocean column. The immediate applicability of BT measurements to the operational concerns of the subsurface warfare community constituted for many line officers the earliest proof of concept for the new model of close-quarters technical engagement with civilian scientists. By 1943, the years of combat experience with the BT and its designers at Woods Hole further convinced a number of officers of the potential lasting significance of oceanographic knowledge for postwar naval strategy and force planning.

Despite these inroads, the warming of the undersea warfare wing of the Navy to civilian ocean science did not portend a corresponding enthusiasm, regarding the role of submarines in particular, from the Navy as a whole. Rather it was the exigencies presented by the German U-boat, and in particular the German fleet's aggressive targeting of Allied commercial shipping lanes, that forced what appeared, by most contemporary accounts, to be a strictly temporary emphasis on fielding new and improved submarine-borne ASW tactics and instrumentation.[61] With the wartime consensus in favor of pursuing an all-out ASW response to the U-boat, the U.S. submarine force took on a markedly greater share of offensive operations than at any point in its pre-World War II history. The World War II experience thus transformed the mission portfolio of U.S. submarines from centering around tactically limited shallow-water operations such as coastal defense and reconnaissance to being thrust onto the frontlines of combat as the sharp edge of the Allied counteroffensive.

[61] I provide a more detailed discussion of the spectrum of opinions that obtained within the Navy regarding the merits of offensive submarine strategy in section three of this chapter.

By 1943, this concerted push had succeeded in placing the German U-boat force on the defensive. As the Allies advanced upon German territory, the pace of R&D activity in undersea warfare applications grew ever more rapid, and the imbrication of oceanographic research with the day-to-day substance of naval operations in turn found ever more frequent and practical expression in the context of wartime realities. For example, beginning in early 1943, Woods Hole, together with the University of California Division of War Research (UCDWR) and the Navy Hydrographic Office (NHO), took on the task of publishing and distributing tactically significant information regarding the acoustical properties of the seafloor in specific areas relevant to the war effort.[62] In the same year, UCDWR personnel invented the first FM sonar-scanning system, and WHOI scientists Maurice Ewing and J. L. Worzel discovered the so-called underwater sound channel, an ocean layer capable of conducting sound signals across thousands of miles as a result of the refraction of sound waves at the top and bottom of the sound channel. Little of what would later come to be recognized as the far-reaching significance of this discovery registered with Navy officials at the time, who proved for the most part unwilling to extend additional funds for sound channel research despite repeated protests from Ewing, Worzel, and others at Woods Hole who claimed it would revolutionize the practice of ASW and naval warfare more generally.

What gave these developments their ultimate long-range importance, quite irrespective of whether they were judged to be of any immediate use in prosecuting the ongoing war at sea, was the influence they exerted on the plans and priorities of civilian scientists and undersea warfare specialists.

[62] Weir, *Forged in War*, 56.

The mounting successes of the Allied ASW campaign combined with the swiftly expanding domain of opportunities for experimentation in the field of underwater sound prompted advocates of Navy-sponsored oceanography to work toward effecting a broad reorientation of R&D efforts further away from traditional defensive applications toward the goal of enhancing the performance of submarines as offensive platforms in their own right. While their success in this endeavor remained far from assured, the final phases of the war in the Atlantic unfolded in a number of ways that strengthened their position within the Navy and the wider military establishment.

The first such development came in the final days of 1944, when Captain Henry Schade, the Navy's top representative attached to the Manhattan Engineering District's scientific intelligence-gathering mission — codenamed Alsos — secured the approval of the serving Commander-in-Chief of the U.S. Fleet and the Chief of Naval Operations to create an independent Navy fact-finding mission under Schade's command.[63] Over the course of the ten months following its establishment on December 26, the Naval Technical Mission in Europe put 309 officers, 109 civilian specialists, and over 100 German and French civilians to work on a mission "to exploit German science and technology for the benefit of the Navy Department technical Bureaus and the Coordinator of Research and Development."[64] The findings of the Naval Technical Mission led to the publication of hundreds of reports on subjects ranging from guided missile design to the living conditions and accommodations aboard German submarines. For subsurface warfare specialists, the Mission's most

[63] Records of U.S. Naval Technical Mission in Europe, 26 December 1944, Naval History Division, Operational Archives, Washington, D.C.
[64] Ibid.

significant discovery by far was the number of experimental U-boat prototypes with depth, speed, and underwater endurance capabilities far in excess of those of any existing submarine in the Allied fleet.

The Type XXI, the fastest of the prototypes, set a defining precedent for the type of future threats American naval R&D planners came to expect going into the postwar period. Its ability to dive deeper, sprint faster, and remain submerged longer than any submarine in the U.S. fleet inflamed the imaginations of Navy officers who saw the Type XXI as an unnervingly close call for a fleet that had already struggled to contain a less advanced U-boat threat. Moreover, reports of advancing Soviet forces having secured a number of these advanced prototypes, including the Type XXI, raised the prospect of encountering such designs amid enemy forces to an inevitability in the eyes of naval intelligence.[65] Nevertheless, despite what appeared to many subsurface specialists to be the clear postwar threat posed by the Soviet Union acquiring German submarine technology, by the end of 1945 no consensus had yet developed within the Navy as to how the service should respond in its long-range plans. As the following section will show, it took years of considerable effort by civilian scientists, industry leaders, and a small but persistent set of naval officers before the service officially signed onto a comprehensive program of prosubmarine and ASW R&D, with ultimately far-reaching consequences for the ongoing debates over unification and the Navy's role in the national air atomic strategy.

Postwar Fragmentation of Naval R&D

[65] Hewlett and Duncan, *Nuclear Navy, 1946-1962*, 72–73.

Soon after the conclusion of World War II, the centrally-directed, coast-to-coast network of laboratories responsible for much of the recent Allied success in ASW saw each of its component institutions split off one-by-one from OSRD/NDRC control and placed under the direction of universities and other private laboratories, with the exception of a small number of facilities and research lines that were transferred to the Naval Research Laboratory.[66] The rapid demobilization of OSRD and its contracting authorities resulted less in immediate reductions in overall funding to underwater sound research than in a general rising sense of uncertainty among civilian scientists regarding the long-term reliability of Navy sponsorship.

As with the leadup to the war, a number of key figures in the field of oceanography, including WHOI's Columbus O'Donnell Iselin, took the lead in attempting to reconsolidate and institutionalize naval investments in the science of undersea warfare. This time around, however, civilian scientists could point not only to their wartime track record of delivering technical insights tailored to the operational challenges that the German U-boat posed for the Navy, but also – and perhaps even more effectively – to the prospect of the United States being scientifically and technologically outpaced by a new enemy with access to the Type XXI, and thus to the capacity to leapfrog the prevailing state-of-the-art in American ASW techniques and instrumentation.

While the demobilization of the wartime federal science establishment had begun in earnest by late 1944, top Navy leaders also took certain actions that allowed proponents of accelerated peacetime R&D to retain a foothold within the planning bureaus of the service. Just as the war in

[66] Weir, *Forged in War*, 68.

Europe officially came to an end in May 1945, Secretary of the Navy James Forrestal approved the establishment of the Office of Research and Inventions (ORI) to oversee all Navy-sponsored research. Under the leadership of its first director Harold Bowen, ORI took over the operations of NRL, the Bureau of Aeronautics' Special Devices Division, and all authority over service policy concerning patents and contracts.[67]

Having long been in the position of the Navy's top R&D manager, Bowen's ambitions extended much further, aiming to bring in addition the Navy's nascent work on atomic energy under the ORI umbrella. His attempt in late 1945 to secure ORI clearance for access to work done under the auspices of the Manhattan Project ran into firm opposition from within the office of the CNO, where – as yet, limited – Navy access to the Manhattan Engineering District was being centralized. CNO Ernest King had recently appointed Captain Thorvald A. Solberg, formerly the Navy's liaison to the Manhattan Project, to monitor all technical developments related to the new field of atomic energy. Guarding this prerogative from all encroachments, even from within the Navy, as Solberg did amounted to more than a mere bureaucratic dispute over lines of jurisdiction.

Rather, what lay at stake in the matter of who controlled the service's atomic power portfolio, particularly at this early juncture in the development of nuclear technologies, was not limited to the capacity to shape what forms those technologies took, but included an opportunity to influence the character of U.S. policy broadly as it related to the ongoing debates over unification. The proposed initiative for restructuring the War and Navy Departments, which had generated fierce controversy

[67] Ibid.

ever since its initial appearance during the years of World War II, became considerably more fraught in light of its implications for how the atomic bomb would be incorporated into the postwar plans, programs, and doctrines of the new military establishment. Top Navy leaders feared the prospects of unification could only spell trouble for their own service's autonomy in an era in which airpower was already ascendant.[68] Given the tight coupling these figures (rightly) perceived between the fortunes of air strategy and those of the military atom, they viewed skeptically and cautiously any claims to push rapidly ahead work on the latter, out of a concern that technical success would ultimately help bolster the position of the former.

Thus, the zeal with which Bowen and the wider naval R&D community proceeded to advocate for the development of naval nuclear power discomfited officers like Solberg and his colleague in the CNO's office responsible for overseeing work on guided missiles and nuclear weapons, fellow Manhattan Project alumnus Rear Admiral William S. Parsons. Where Bowen strongly favored the Navy beginning its own independent program of nuclear development, Solberg and Parsons considered maintaining the Navy's collaboration with the Manhattan Project to be the only viable path forward for the development of naval nuclear applications.[69] These clashing visions of how to protect the Navy's interests in the as yet still highly centralized national nuclear establishment highlighted a basic tension at the center of what has often been characterized as "the Navy position"

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[68]Jeffrey G. Barlow, *Revolt of the Admirals: The Fight for Naval Aviation, 1945-1950* (Washington, DC: Brassey's, 1998), 24; Demetrios Caraley, *The Politics of Military Unification: A Study of Conflict and the Policy Process* (New York: Columbia University Press, 1966), 29–30; Steven L. Rearden, *The Formative Years 1947-1950*, History of the Office of the Secretary of Defense□; v. 1 (Washington, D.C.: Historical Office, Office of the Secretary of Defense, 1984), 388–89.

[69] Hewlett and Duncan, *Nuclear Navy, 1946-1962*, 26.

on unification.[70] That is, the independence which service leaders saw to be under threat, and which they sought to preserve at all costs, was only one (and arguably derivative) of several postwar priorities identified by naval officers as being key to maintaining the organization's long-term viability.

In other words, where Navy leaders viewed warily any developments which stood to strengthen the case for unification — chief among these being a commitment to investigating the applications of atomic energy — many of those most thoroughly enmeshed in the world of Navy-sponsored R&D believed that such a commitment was already in the offing, and thus that the more fundamental threat to Navy independence emanated from the service being kept at arm's length from ongoing R&D efforts in the area of atomic energy. Outside of Bowen and the ORI, those most interested in the immediate pursuit of naval nuclear applications were the same civilian scientists whose wartime work on underwater sound had first helped to raise the Navy's estimation of the value of basic research, both as a source of novel methods, techniques, and instrumentation as well as a means of forecasting technological futures. As section four of this chapter will show, the path to nuclearizing the Navy went through the advanced submarine and the communities which strove to place this platform at the center of postwar naval strategy. Before we can trace this trajectory, however, we must first attend to the political battles that Navy leaders fought (and often lost) in the years leading up to the passage of the 1947 National Security Act (NSA), and the ways in which those developments opened up new opportunities for the community of undersea warfare partisans to remake the Navy's strategic policies and its long-term R&D agenda.

[70] Caraley, *The Politics of Military Unification*.

Overseas Transport and Undersea Warfare

The years of 1945 and 1946 represented a decisive juncture in the debates over whether and how to implement a unification of the War and Navy Departments. Since the beginning of the controversy in 1943, Navy leaders expressed strong opposition to this initiative to streamline the military, primarily due to concerns that under such a scheme naval aviation would be subsumed under the control of the ascendant Army Air Forces.[71] While the matter of unification was quickly forced to take a backseat to the war effort, the conflict erupted with renewed intensity as soon as the fight abroad had run its course. In October 1945, the same month in which Bowen officially began his duties as the first director of the newly constituted ORI, the Senate Military Affairs Committee began hearings on two distinct unification bills.

The first proposal, introduced in April of that year by the Joint Chiefs-appointed Richardson Committee, represented a compromise on the fundamental sticking point of the fate of naval aviation, which it held should not be eliminated for at least another decade and only with the unanimous vote of the Joint Chiefs of Staff.[72] Unsurprisingly, the uniformed Navy remained decidedly against the Richardson Committee proposal. In response, Secretary Forrestal – reading the political winds then pointing to the passage of some form of unification as inevitable, and thus the Navy position of unequivocal opposition as untenable – appointed a committee headed by former Army-Navy

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[71] Rearden, *The Formative Years 1947-1950*, 390.

[72] The chairman of the four-man committee, Admiral James O. Richardson, himself dissented from the recommendations offered in the majority report. Ibid., 385.

Munitions Board Chairman Ferdinand Eberstadt to study the unification problem and its implications for "national security."[73] Unlike the Richardson Committee report, which had concerned itself narrowly with the issue of military organization, the Eberstadt Committee framed its recommendations for the restructuring of the War and Navy Departments in terms that emphasized the national security implications of any proposed plan for unification.

Navy leaders greeted the work of the Eberstadt Committee with relief and quickly ran with the recommendations of the final report, incorporating many of its proposals into a formal department press release branded as "The Navy Plan for National Security."[74] The stage thus set, the October 1945 Senate hearings pitted the Navy's plan for unification against the Army-favored Richardson proposal. Acrimony quickly ensued. Lieutenant General James Doolittle of the Army Air Forces put it this way:

> The carrier has two attributes. One attribute is that it can move about; the other is that it can be sunk. As soon as airplanes are developed with sufficient range so that they can go any place that we want them to go, or when we have bases that will permit us to go any place we want to go, there will be no further use for aircraft carriers.[75]

The hearings thus became the opening salvo of a two-year battle over which lines would be drawn and where in the postwar allocation of land- and sea-based air assets. Within days of the hearings' conclusion, President Truman expressed to congress his support for an independent Air Force with authority over all land-based aviation, "including naval reconnaissance, anti-submarine

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[73] James Forrestal and Walter Millis, *The Forrestal Diaries* (San Francisco: Lucknow Books, 2014), xxiii.

[74] Cecilia Stiles Cornell, "James V. Forrestal and American National Security Policy, 1940-1949" (Ph.D., United States -- Tennessee, Vanderbilt University), 283.

[75] Congress, Senate, Committee on Military Affairs, *Department of Armed Forces, Department of Military Security,* 79th Cong., 1st sess., 9 November 1945, 308. Quoted in Mark D. Vital, "The Key West Agreement of 1948: A Milestone for Naval Aviation," (M.A., United States -- Florida, Florida Atlantic University), 19.

patrol, and protection of shipping."[76] In subsequent talks mediated by the White House, in May 1946, Secretary Forrestal declared in no uncertain terms that such a policy would run directly counter to the Navy's core mission, writing in a formal opposition memo that in order for the service to fulfill "its fundamental purpose, the Navy needs a certain number of land planes for naval reconnaissance, antisubmarine warfare, and protection of shipping."[77] Writing in his diary of a later meeting that June:

> I said that the Navy Air people were greatly disturbed over that passage in his letter which dealt with the land-based reconnaissance planes. I said the Navy felt so strongly as to be fanatic about it, that they *must* have the means to carry out their mission.[78]

As happened the previous year, the president ultimately sided with the Army, holding firm to the position that independent Air Force personnel should exercise control over all land-based aircraft, including those used for naval reconnaissance, anti-submarine warfare, and the protection of shipping. In turn, congress again provided a platform for Navy voices to testify against the transfer of their aviation arm to the Army Air Forces. This pattern of private deadlock and public dissent continued as lawmakers debated and revised the language of the compromise unification bill sent by the Truman administration in February 1947 throughout the subsequent spring and summer, up until the final passage of the National Security Act in July 1947.

Far from obtaining the clear legal jurisdiction they sought over naval aviation in the final bill, Navy leaders found themselves on the other side of unification fighting the same battles, though now against an even stronger opposition in the newly established Air Force. Executive Order 9877, signed

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[76] Harry S. Truman, *Memoirs*, [1st ed.] (Garden City, N.Y.: Doubleday, 1955), 50.

[77] U.S. Congress, *Congressional Record*, Volume 92, Part 6, 7425.

[78] Forrestal and Millis, *The Forrestal Diaries*, 169.

by Truman in conjunction with the NSA, laid out the roles and missions of the services according to a directive written by Admiral Forrest Sherman and Army Air Force General Lauris Norstad the preceding January. Having reflected only the compromises of the earlier year and none that were secured in the six months thereafter, Executive Order 9877 contained none of the same assurances for the retention of its traditional mission specialties that the Navy had fought to get incorporated into the NSA. With respect to naval reconnaissance, ASW, and shipping protection, the order declared that:

> The Air aspects of those functions shall be coordinated with the Air Force, including the development and procurement of aircraft, and air installations located on shore, and use shall be made of Air Force personnel, equipment and facilities in all cases where economy and effectiveness will thereby be increased.[79]

This stark departure from the guidelines set out in the NSA, which had dubbed these same functions the responsibility of the Navy alone, immediately reignited the opposition of the Navy and set the stage for another series of pitched battles over roles and missions within a dramatically restructured national military establishment. Importantly, this controversy took place simultaneously alongside the Truman administration's drive to eliminate deficit spending in the fiscal year 1949 budget. For the Navy, this reality meant that the continued vulnerability of their carrier fleet and naval air assets was not only a matter of doctrine. An inability to maintain a hold on their strategic claim to a naval stake in national air power would translate not only into a loss of prestige but would further mean the loss of service autonomy over long-range plans and programs. The 1949 cutbacks in the defense budget provided a vivid illustration of just such a trend in its slashing of significant funds for

[79] Quoted in Mark D. Vital, "The Key West Agreement: A Milestone for Naval Aviation," (M.A., United States -- Florida, Florida Atlantic University), 40.

both the building of the *USS United States* – the Navy's first flush deck supercarrier – and proposed ASW programs.

It was in the context of this fraught period for the Navy that undersea warfare officers, civilian scientists, and industry personnel sought to reconsolidate the institutional channels that had – for each of their respective agendas – rendered their wartime collaborations so effective. Attempting such a feat in the austerity-prone budgetary environment of the late 1940s required private researchers in particular to take the lead in organizing new channels for directing the two-way flow of Navy dollars and scientific expertise. In terms of the motivations animating civilian scientists, Columbus Iselin put it clearly in a letter he wrote to a WHOI colleague in the first year after the war, saying that "only through the government can we hope to finance oceanography adequately," a task which he saw could only be accomplished by encouraging the Navy to define its needs as broadly as possible.[80]

Central to this undertaking was ORI (after August 1946, the Office of Naval Research). Despite its initial budget of $50 million being roughly halved within months of its establishment, ONR quickly became a clearinghouse and prolific sponsor for new research in underwater sound. Its annual Undersea Warfare Symposium, the first of which was held in September 1946, served to professionalize the ranks of civilian scientists and junior officers with shared interests in underwater sound, physical oceanography, and the myriad technical intricacies of subsurface operations. In addition to fostering a deeper identification between naval officers and ocean scientists, a principal concern of the senior scientists that had been in charge of much of the World War II underwater

[80] Gary E. Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment*, 1st ed., Texas A & M University Military History Series 72 (College Station: Texas A&M University Press, 2001), 208.

sound work was retaining and expanding the interest of their peers in academia in joining the network of undersea warfare R&D.

In November 1945, Gaylord P. Harnwell, formerly the director of the University of California Division of War Research, wrote a letter to Admiral Bowen at ONR proposing the establishment of a formal committee to monitor, facilitate, and disseminate scientific advancements of interest to the Navy. Within a year of his writing, representatives from a number of naval offices, laboratories, and civilian research institutions met to solicit Bowen's approval for such a committee under the auspices of the National Research Council (NRC). Attended by figures like John Tate, Columbus Iselin, Cornell's Detlev Bronk, the soon-to-be president of Johns Hopkins University, and MIT's Philip Morse, an early founder of the field of operations research who had first applied these principles in the wartime ASW context, these meetings eventually succeeded in persuading Bowen to agree to found such a committee on October 23, 1946.[81]

By the following June, the contract between ONR and the National Academy of Sciences had been signed and the Committee on Undersea Warfare (CUW) officially chartered. With NDRC alumnus John Tate as its first chairman, and Harnwell in the role of Tate's deputy, the CUW became responsible for reviewing, analyzing, and evaluating the R&D programs of the entire Navy Department, as well as for proposing additional fields of investigation. The CUW's expansive mandate placed this rather small group of scientists in a position to influence the future direction of naval

[81] Weir, *Forged in War*, 125.

R&D, not only by way of evaluating existing programs, but also by defining the realm of technical possibility over the short-, medium-, and long-term.

Immediately following its establishment, the CUW took over the responsibility of convening ONR's annual Symposium on Undersea Warfare. The priority areas that dominated CUW attention in the first years of its existence were underwater sound, hydrodynamics, hull design, and modes of ship propulsion. These particularly active sites of applied research, which had coalesced in response to the discovery of advanced U-boat prototypes at the end of World War II as well as the prospect of naval nuclear energy, taken together served to raise both the scientific and operational profile of the submarine. In light of the submarine's capacity to serve as both a platform for data-collection as well as a weapons system, the crash program to convert fleet submarines into Type XXI variants yielded not only faster subs (called Guppys, due to their "Greater Underwater Propulsive Power) but a means of experimenting with a range of ASW and prosubmarine techniques and instrumentation. The results of this initiative prompted a growing interest in the problem of submarine "self-noise" – or the various means by which submarines generated sound in the course of their normal operations. The sources of submarine self-noise were numerous, in a sense a function of the number of moving parts whose vibrations could be transmitted through the body of the submarine's hull to the surrounding ocean environment. Minimizing this phenomenon formed the overarching objective of prosubmarine R&D, and required a comprehensive program of investigation into the dynamic properties of various hull forms, silencing mechanisms, and essential pieces of externally-mounted instrumentation when in motion through a fluid medium.

To this end, on July 20, 1948, Admiral Solberg, then head of ONR, directed CUW members to convene a panel on the "hydrodynamics of submerged bodies," devoting special attention to addressing the problems of "forward motion stability, resistance, depth control, effects of excursions in depth, and surface effects at high speeds."[82] Before issuing its interim report in November 1949, the panel distributed two memos asking in turn for continued support on submarine problems and for an immediate collaboration between the Navy and industry to design and build an advanced experimental research submarine capable of reaching speeds upwards of 20 knots while submerged.[83] As section four of this chapter will describe, the product of this collaboration would be the *USS Albacore*, whose teardrop-shaped hull design represented a proof of concept for the tactical utility of both fast subs and a prototype production model of R&D evaluation.

Following on the heels of the CUW panel's interim report, the Chief of Naval Operations Admiral Denfeld commissioned another study, this time on the ASW problem. Vice Admiral Francis S. Low chaired the body, which met from January through April 1950. Low was strongly influenced in his thinking on the threat of future ASW by the testimony of Captain William Ignatius (of the Naval Technical Mission in Europe), who predicted a postwar "revolution" in undersea warfare as a result of the greater speed, diving ability, and endurance of the advanced German U-boat designs.[84] Taking seriously the proposition of an ASW revolution on the horizon, the final Low Report recommended that the Navy pursue the full gamut of ASW platforms, methods, and weapons

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[82] Ibid., 132-133.

[83] Patrick Tyler, *Running Critical: The Silent War, Rickover, and General Dynamics*, (New York: Harper & Row, 1986), 57-59.

[84] Weir, *Forged in War,* 99.

systems, including both surface and subsurface basing modes for guided missiles and acoustic pattern-running torpedoes. In addition, the Low Report recommended work on both nuclear and closed-cycle propulsion for submarines, as well as further research in the art of submerged detection.

What necessitated these measures, the report argued, was the inevitability of the Soviet ASW threat to U.S. shipping and naval forces given the U.S.S.R.'s own acquisition of several Type XXI U-boat prototypes. The unassailability of this assumption – that Soviet access to the Type XXI meant it would immediately undertake a crash program of ASW R&D – had with the publication of the Low Report, and in the aftermath of the first Soviet atomic test, become an article of faith within the undersea warfare community. Precisely how this faith in the threat from Soviet ASW served the project of consolidating support for submarines is the subject of the following section. Within a month of the Low Report's appearance, yet another group would convene to discuss in far more detail the nature of the expected threat and the paths they considered open to the Navy in meeting them. The Hartwell summer study, as this group's work came to be known, would give technical (more accurately, technopolitical) form and direction to the ASW agenda laid out in the Low Report.

On January 23, 1950, hardly three months after the dust had settled on Capitol Hill following the admirals' revolt, the Deputy Chairman of the National Research Council Committee on Undersea Warfare, G. P. Harnwell, sent a letter to Admiral Charles B. Momsen, the Assistant Chief of Naval Operations responsible for the Navy's undersea warfare portfolio. Harnwell's message was clear: the Navy could afford to waste no time in convening a comprehensive high-level study on the challenges and opportunities facing subsurface operations in the postwar period. These issues, as Harnwell and his colleagues saw them, included "(a) transport and cargo handling, (b) vehicle and weapon systems,

and (c) submarine defense" -- all of which were framed as being in need of a radical rethinking in light of the threat posed by advanced-type submarines.[85] Within a few weeks of Harnwell's proposal, Momsen, along with ONR Chief Admiral Solberg, was already busy assembling the necessary personnel to undertake just such a study. With the ready cooperation of Bell Labs President Melvin D. Kelly and MIT Provost Julius A. Stratton, ONR and MIT jointly brought together a total of 33 scientists whose work on the study would by spring's end become known as the Hartwell Project.

Mostly hailing from a small handful of universities dominated by MIT, Harvard, and Johns Hopkins, the Hartwell group also featured strong representation from private industry and government laboratories, all of whom shared an extensive list of common research interests in the areas of radar, acoustics, and electronics. Their 3-month collaboration over the summer of 1950 culminated in a report on what they termed the "problem of overseas transportation," a product Hartwell scientists freely admitted went far beyond the terms of reference for the study they had been assigned addressing "the technical barriers that now limit the effectiveness of anti-submarine and anti-mine warfare." Having been assured by their Navy patrons that Hartwell was "not simply an evaluation group" and that instead their findings would be looked to for "guidance on future long-range plans," Hartwell scientists saw no reason to limit their recommendations to the operational problems of the day, and instead looked to the future as a guide for identifying R&D areas they sought to bring to the attention of Navy leadership. By the end of September, they produced an over 440-page-long, two-volume report detailing their evaluations and recommendations in eleven different functional

[85] "A Report on Security of Overseas Transport: Volume II" (Massachusetts Institute of Technology, September 21, 1950), K-1.

specialties deemed relevant to the ASW mission and what they argued constituted the broader predicament of the United States' newfound vulnerability to attack from the sea.

Undergirding the Hartwell group's ambitious slate of proposals was its central motivating claim that the Soviet Union would soon be capable of operating submarines equipped with nuclear-tipped missiles, rendering U.S. coastal populations and infrastructure defenseless in light of contemporary limitations in ASW tactics and capabilities. In advancing such a claim, Hartwell scientists were in part responding – in much the same way as others throughout the national military establishment – to the previous September's revelation that the Soviet Union had conducted its first nuclear test, officially ending the American monopoly on the atomic bomb years ahead of the schedule projected by U.S. intelligence.[86] News of the Soviet test significantly strengthened the hand of R&D proponents across the military services, particularly for those interested in pursuing further the military applications of atomic energy (discussed at length in the following section). For the Hartwell group, it was a relatively straightforward matter to press the advantage offered by the climate of urgency that prevailed in the months following the Truman administration's dramatic announcement of the Soviet test, and that climbed to a fever pitch of anxiety after the outbreak of the Korean War in June of 1950.

Dismissing as a "myth" the claim that atomic weapons could only be militarily effective against large cities, Hartwell scientists took pains to describe what they alleged would be the wartime cost of neglecting to develop *tactical* applications for atomic weaponry, i.e. applications that targeted

[86] Michael D. Gordin, *Red Cloud at Dawn: Truman, Stalin, and the End of the Atomic Monopoly*, 1st ed. (New York: Farrar, Straus and Giroux, 2009).

adversaries' military forces and associated installations. In doing so, they went further than simply arguing that such applications stood as a complement to the dominant strategic rationales then being widely deployed as justifications for the growing U.S. nuclear stockpile. Instead, they stated unambiguously in their final report that "the tactical *rather than* strategic uses of fission weapons will be of the utmost importance in a future war."[87]

On the basis of their own heuristically derived notional values for the performance penalties that would be incurred through proposed reductions in the size and weight of existing warheads, the Hartwell group went on to conclude "that for many purposes it may be highly preferable to accept such a loss in range [of target damage] in exchange for the possibility of using tactical atomic weapons that are more effective from the point of view of availability, flexibility, and accuracy of delivery than are large air-dropped atomic bombs."[88] The close attention paid by Hartwell participants to the concrete operational implications of developing relatively small, lightweight nuclear weapons was a direct nod to the arguments made by naval officers in their congressional testimony the previous year.

Much of the extensive list of R&D proposals the group deemed urgent appealed directly to the interests of the Navy's demoralized surface-air community. For example, some of the report's most emphatic recommendations were reserved for the development of new carrier-based aircraft equipped with tactical nuclear weapons, which Hartwell personnel identified as key not only to hunting enemy submarines but also to the task of destroying coastal military installations and even inland targets. The

[87] "Project Hartwell Final Report, Vol I," A-7. Emphasis added.

[88] Ibid., A-8.

report would go on to make explicit the nature of the link Hartwell scientists supposed connected the need for smaller warheads to the future of undersea warfare:

> In summary and as a general theorem, we can state that, other things being equal: the smaller and lighter a bomb, the greater will be the scope and frequency of application against military targets. It is, therefore, of great practical importance that we aim for the smallest and lightest design practicable in the present state of the art…[I]t is already clear that the cost of reducing size and weight of atomic weapons in order to make them practical for tactical uses is one that we can afford to bear. Indeed, tactical atomic weapons are weapons that we cannot afford to ignore. *Atomic weapons are cheap in comparison with the damage that a submarine can do.* A sure kill [of an enemy submarine] may save a large part of a convoy or a carrier task force, or leave in operation a port that might otherwise be knocked out.[89]

Understanding the full significance of these claims requires placing them in the context of what the report's authors termed "the facts of atomic energy in 1950," as well as the relevant though only obliquely referenced facts of the international situation then facing the Navy and the country at large. Hartwell scientists devoted considerable space in their final report to tackling one-by-one the "dangerous misconceptions" they saw as shaping the contemporary thinking of many civilian and military planners. Some of the claims they were loudest in refuting concerned the expected availability and usability of atomic weapons.

In response to claims of atomic scarcity, Hartwell scientists provided uncited estimates that the U.S. in all likelihood had in its possession "several hundred atomic bombs…costing between one and five million dollars each." Their subsequent recommendation that a force of 10,000 atomic weapons be programmed to meet the demand that would be generated by tactical applications could thus only be read as "cheap" in light of the assumption, advanced early and often throughout the report, that

[89] Ibid., A-9-10. Emphasis added.

Soviet submarines would soon be armed with nuclear weapons and capable of using them in large numbers against U.S. ships and commercial ports. In a subtle reversal of the standard opportunity-cost logic, Hartwell scientists argued that neglecting to use tactical atomic weapons for ASW would prove much costlier in terms of wartime damage than the investment required to develop and deploy an arsenal sufficiently large and flexible to target Soviet submarines. Given the fact that at the time $4 million was approximately equivalent to the unit cost of a B-36, "cheap" here was indeed a relative term whose credibility relied on taking seriously the prospect of an imminent threat to commercial and military centers on the U.S. homeland from nuclear-armed Soviet submarines.

Exactly how this threat was to be assessed apparently drew conflicting judgments from the Hartwell group, in stark contrast to their unanimity on the shape of the necessary response. Having declared it "axiomatic that the U.S.S.R. will concentrate on measures designed to jeopardize shipping," Hartwell scientists began their assessment of contemporary Soviet capabilities by laying out one far-reaching, essentially unfalsifiable assumption -- "that the U.S.S.R. will manufacture and use mines, submarines, and submarine weapons, *despite any intelligence that may seem to indicate the contrary*."[90] As baldly as the group advanced this premise in the earliest pages of the report, they just as easily recommended "that an extraordinary effort be made to obtain accurate information on the U.S.S.R. production of atomic weapons...[and] should utilize the most critical and imaginative scientists and engineers."[91] As difficult as it would appear to be to reconcile such pronouncements, the

[90] Ibid., 2. Italics mine.

[91] Ibid., A-6.

tension in their appearing practically side by side itself contains a degree of insight as to what the Hartwell study participants considered to be the future role of intelligence collection in military R&D.

Throughout the earliest years of the Cold War, the American intelligence community both inside and outside the ranks of the military was as divided on the particulars of the Soviet nuclear program as it was united on the need to know more.[92] Published nearly a year to the day after President Truman announced that the U.S. had detected the Soviet Union's first nuclear test, the Hartwell report made repeated mention of the fact that little was yet known about the size and rate of growth of the Soviet arsenal. This uncertainty itself, however, did not register as posing any particular problem for the substance of the report's recommendations on necessary "countermeasures." How such uncertainty could coexist alongside such confidence becomes straightforward only when one considers the fact that intelligence collection was at no point in the Hartwell report offered as a means of guiding R&D choices. On the contrary, intelligence collection as it related to the task of defining the precise shape and scale of Soviet efforts in atomic weaponry was portrayed simply as one more functional domain in need of a focused R&D effort to address perceived gaps in reconnaissance capabilities. Indeed, the only concrete projection of Soviet force developments hazarded by the Hartwell group was stated in the following terms:

> By September, 1952, the U.S.S.R. can have a fleet of several hundred modern submarines equivalent in performance to the German Type XXI or the Guppy-snorkel. At a minimum, the

[92] There exists an extensive literature on the subject of the U.S. Intelligence Community and its attempts to establish reliable estimates of Soviet capabilities and intentions throughout the Cold War. For works most relevant to the juncture discussed here, see Prados, *The Soviet Estimate*; Gordin, *Red Cloud at Dawn*; Ford and Rosenberg, *The Admirals' Advantage*.

> U.S.S.R. will have 200 to 300 submarines, snorkel-equipped but otherwise comparable to current U.S.S.R. types. The Soviet construction capacity will be 100 such submarines per year.[93]

Here the Hartwell group was carrying on the intelligence community's tradition of projecting into the future (and without revision) the unconfirmed estimates of projections past.[94] In fact, between 1949 and 1958 the Soviet Union deployed only 21 of its Zulu-class (Type XXI) snorkel-equipped submarines, and took the same amount of time to deploy 236 Whiskey-class submarines, whose size and endurance limitations confined them to operate primarily in coastal waters around the Soviet Union.[95] Hartwell scientists' claims about the urgency of the threat posed by Soviet submarines, and the distance separating these claims from reality, can be understood with reference to one of the report's most significant recommendations, namely that:

> The separation of measure development from countermeasure development, whether by secrecy barriers or by organizational structure, is detrimental. The two developments should interact. They should be administered by the same director...It is not enough to evade enemy attacks upon our ships. We must subject the enemy's weapons of attack to attrition.[96]

By advocating for the integration of R&D efforts in formally antagonistic functional specialties, Hartwell scientists made clear that they believed the state-of-the-art in any field could not afford to be dictated by the estimated pace of Soviet developments, but rather should be made to anticipate them by looking to real-time, in-house efforts in ASW and advanced submarine design in

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[93] "Project Hartwell Final Report, Vol I," 2.

[94] In 1946, Naval intelligence forecasted a Soviet force of 300 Type-XXI caliber submarines by 1950. See Owen R. Coté, *The Third Battle: Innovation in the U.S. Navy's Silent Cold War Struggle with Soviet Submarines*, Newport Paper□; No. 16 (Newport, R.I.: Naval War College, Center for Naval Warfare Studies, 2003), 18. Michael Gordin describes a similar phenomenon with respect to American estimates of Soviet progress toward a bomb in *Red Cloud at Dawn.*

[95] O. R. Coté, *The Third Battle*, 18.

[96] "Project Hartwell Final Report, Vol I," 13.

the United States. Embedded in this recommendation was a layered critique of prevailing secrecy practices and of what the group considered an overly conservative approach to addressing the vulnerabilities of existing naval forces.

Secrecy, Hartwell scientists argued, hobbled the military's technical and operational personnel in their search for solutions to the problem of vulnerability in the nuclear age. They held that, all too often, information that could aid in discriminating among proposed solutions on the basis of technical feasibility, cost, and operational effectiveness remained locked behind organizational screens in a national military establishment fragmented by the stringent need-to-know barriers erected by the Atomic Energy Act of 1946. Given their assessment of the poor intelligence outlook on both the home front and abroad, the Hartwell group concluded that the only option was to pursue programs that, in effect, cut both ways, such that improvements in submarine design automatically planted the seeds of future ASW countermeasures.

Hartwell scientists offered this arrangement as a means of obviating the demand for accurate, real-time intelligence on both present and future developments in the Soviet Union's atomic force structure. They argued that placing R&D on an independent footing in the form of what they considered a suitably self-contained, virtuous cycle would in turn enable intelligence to serve as merely a scaling function rather than as a direct guide for the military's force planning. The cost of poor intelligence then was not necessarily building the wrong weapons, but that "the scale of our effort

must be greater, since we must then provide counter-measures for all possible weapons instead of all probable weapons."[97]

The implications of such a wholesale integration of R&D activity for contemporary diplomacy did not bear mentioning, as in the Hartwell report's sketch of the world situation the authors had already concluded that "[i]nternational control is today as 'unthinkable' as war in the 'atomic age' five years ago."[98] Displaying a comparable level of interest in other pressing facts of the international situation in 1950, the Hartwell final report breezily dismissed the implications that the Korean War – the outbreak of which took place less than three weeks into the work of the summer study – would have for U.S. naval force planning, instead characterizing the conflict as a distraction from the threat of "all-out-war" that ought to be driving the Navy's long-term planning efforts in R&D.[99]

In fact, the Korean War soon proved in a number of ways to be a watershed in the trajectory of oceanographic research of major consequence to the Hartwell group and their colleagues throughout academia, industry, and the uniformed Navy. Not only were several areas of active research saved from impending cutbacks in light of the sudden reversal of downward funding trendlines for the military that accompanied the outbreak of that conflict, but the particularities of the Navy experience operating in the coastal waters off the Korean Peninsula served to underscore in the minds of many officers the need for a comprehensive program of research in the domain of undersea warfare. During

[97] "Project Hartwell Final Report, Vol I," 13.

[98] Ibid., A-1.

[99] Ibid., 1-2.

the war, Soviet underwater mines laid by North Korean forces accounted for 70% of all U.S. Navy casualties.[100] The operational setbacks caused by these mines at one point led Rear Admiral Allan Smith, in command of the advance force at Wonsan, to cable Washington his frustration that "we have lost control of the seas to a nation without a Navy."[101] In light of the lessons being learned daily from the Korean War, even officers who viewed skeptically the advice of civilian scientists on military matters grew more inclined to accept and support the need for an aggressive R&D push along the lines proposed in the Hartwell report.

The complex international environment that surrounded the work of Hartwell participants was compounded by the political challenges stemming from intra-Navy contests for control over the service's R&D priorities. The years spanning and immediately following the Korean War saw ONR struggle to carve out a durable base of support within a Navy hierarchy that yet had no dedicated R&D representative on the staff of the CNO. Solberg as Chief of Naval Research had numerous times managed to fend off attempts to wrest ONR from its privileged position under the civilian Navy secretariat and place it under the immediate jurisdiction of the CNO's office. The price for ONR's continued autonomy from the fleet, however, was an obligation to take the lead role in managing the full panoply of naval R&D programs, a job which immediately put all ONR-funded research in the crosshairs of Navy bureaus with competing R&D agendas. The fact that the great majority of Hartwell proposals found themselves taken up and pursued over the course of the early 1950s speaks to the

[100] In total, 5 U.S. Navy ships were sunk and 87 damaged in the Korean War. See Spencer Tucker and Jinwung Kim, *Encyclopedia of the Korean War: A Political, Social, and Military History* (Santa Barbara, Calif.: ABC-CLIO, 2000), 148.
[101] Ibid., 453.

success with which Hartwell scientists were able to give voice to the full range of their Navy sponsors' aspirations in a language that proved simultaneously compelling to operational personnel and readily translatable into research grants.

This alignment did not come about by chance. The scientists working on the Hartwell project in the summer of 1950 began their work in part on the sidelines of the Fifth Undersea Warfare Symposium, jointly organized by ONR and CUW and held in Washington, DC. There, unlike in previous years, the civilian scientists representing academia and private industry lobbied for fewer technical presentations in exchange for more presentations from current officers that demonstrated where their research fit into the grand scheme of contemporary naval doctrine and force planning.[102] This sudden interest in the finer points of naval strategy and operations stemmed from a widespread concern about the long-term reliability of ONR funding for the budding community of civilian ocean scientists. Certainly the events of the first half of 1950 had impressed upon those at the symposium a vivid sense of just how close Navy leadership was to turning off the valve of research funding that had been financing the vast majority of their work since World War II.

Just that January, at the same time that Gaylord Harnwell of the Committee on Undersea Warfare was writing Navy leaders to solicit interest in a formal study of ASW opportunities, ONR was being audited. The CNO installed in the wake of the previous fall's dustup on Capitol Hill had a mandate: to carry out the $376 million in cuts that had been handed down by the Truman administration as it resolved to bankroll, partly out of the Navy's budget, the procurement of more B-

[102] Weir, *An Ocean in Common,* 301.

36 bombers. In the ensuing search for cost savings, Sherman had sent Vice Admiral Oscar C. Badger to review ONR's Contract Research Program, which in the early years after World War II had focused almost exclusively on supporting basic research led by university scientists, to the tune of fully half of the office's overall budget. Over the course of Badger's two-week-long inquiry, ONR administrators found themselves scrambling to fine-tune project rationales that would pass muster with the short-tempered combat veteran whose service record had never brought him into especially close contact with Navy-sponsored research. ONR staff quickly discovered that the only arguments likely to find a sympathetic ear with the admiral were those that placed the operational needs of the Navy front and center.

ONR managed to come out favorably in the ultimate report Badger submitted to the CNO, much to the chagrin of top officials within the Navy who remained unconvinced of the need to support university research in the face of an increasingly cash-strapped fleet. By the end of February, the Navy's General Board moved to seek a second opinion by prompting Sherman to appoint yet another admiral to lead a follow-up inquiry into ONR activities, this time explicitly for the purpose of "a closer integration of research and development activities in the Navy."[103] As the Undersea Warfare Symposium was convening over May 15-16, this upcoming review still hung over the heads of the attendees' ONR hosts, and only the subsequent outbreak of war on the Korean Peninsula saved the office from another stint on the Navy's fiscal chopping block. Among the conferees, Hartwell participants were nevertheless some of the most optimistic about the long-term prospects for research.

[103] Harvey M. Sapolsky, *Science and the Navy: The History of the Office of Naval Research* (Princeton University Press, 2014), 62.

One Hartwell attendee in particular, Professor Frederick "Ted" Hunt of Harvard, delivered what by many accounts was remembered as a "bombshell" report on the military applications of the recently-discovered deep sound channel – a region of the ocean whose acoustic properties allowed sounds to travel extraordinary distances. Having roused the audience, Hunt concluded on a note of good cheer, saying "to my colleagues in sonar: have heart, boys, we're back in business again." [104]

Hunt was correct – the business of underwater sound was soon booming, and not simply as the result of another war. Since before the country's entry into the last war, Hunt and his colleagues in the nascent field of underwater sound had been hard at work cultivating Navy interest in the possible operational applications of their discoveries. In fact, the deep sound channel itself was a wartime discovery. Maurice Ewing, then at Woods Hole Oceanographic Institution, had postulated its existence back in 1937 and as early as 1942 conducted experiments demonstrating the potential to detect sound signatures at regular intervals thousands of miles removed from the sound source. Still, these results failed to attract much interest among Navy officers at the time and for years after the end of World War II, largely on account of there being no clear sense of how to use such a capability in an offensive mode.

The summer of 1950 worked to dramatically shift these perceptions within the undersea warfare branch of the Navy. Hartwell participants' recommendation that the Navy commit approximately $10 million per year (the equivalent of $113 million in 2020) toward the development of a long-range passive sonar system for undersea surveillance resulted in a number of new contracts

[104] Weir, *An Ocean in Common,* 301.

for the Bell Telephone Laboratories and Western Electric divisions of the American Telephone and Telegraph Company, as well as for university-based researchers interested in conducting large-scale studies on the physics of underwater sound across diverse ocean environments. Nevertheless, as formative as its contributions would soon prove, it would be a mistake to credit the Hartwell project as being solely responsible for the realignment of Navy interests in favor of pro-submarine and ASW R&D.

Getting to the root causes of this change and its far-reaching consequences for naval and the broader national military strategy requires understanding another set of contemporary developments in the world of Navy-sponsored R&D: nuclear propulsion. The drive to harness atomic energy to power the Navy's ships constituted one of the most ambitious and divisive technological initiatives of the early postwar period. And as the following section will make clear, those whose determined pursuit of the "true submarine" – that is, one with unlimited underwater endurance – had alienated much of the uniformed Navy found dedicated allies among the community of undersea warfare specialists. In turn, the latter's political cachet and salience within Navy doctrine rose in tandem with that of the nuclear submarine.

Quieting the Nuclear Navy

In the five years that separated the end of World War II from the outbreak of the Korean War, the ASW mission and its associated range of R&D priorities had gone from a set of ad hoc wartime expedients to rapidly widening areas of primary strategic significance for the Navy. In explaining this

shift, the foregoing sections have focused their analysis on the role of ASW advocates and their proactive efforts to bring about just such a transformation. In this section, by contrast, I examine the role played by advocates of naval nuclear propulsion in driving, at times reluctantly, the Navy's growing financial and doctrinal investment in submarines. The notion of placing a nuclear reactor aboard a submarine provoked a diverse array of objections from practically every corner of the Navy Department. These reservations stemmed in part out of concerns regarding safety, technological feasibility, and standing R&D commitments to other modes of ship propulsion. As we will see, addressing (and at times suppressing) these concerns required atomic energy advocates to build, from the ground up, the base of political, organizational, and technical support necessary to get the Navy "underway on nuclear power."[105]

Significantly, Navy-sponsored work on atomic energy began in the spring of 1939 under the leadership of Ross Gunn at NRL — three years before the establishment of the Manhattan Project. After attending a March 17 briefing by the newly Nobel-minted physicist, Enrico Fermi, Gunn had within three days organized a group of eight NRL researchers in addition to the lab's then director Captain Hollis Cooley to call on then Rear Admiral Bowen (who was at the time Chief of the Bureau of Engineering) to secure a sum of $2,000 to "initiate the first steps in the solution of the uranium power problem."[106] From these modest beginnings, Navy-sponsored research in atomic energy branched out from Gunn's NRL group to a handful of private institutions through NRL contracts,

[105] Hewlett and Duncan, *Nuclear Navy, 1946-1962*, 217.

[106] Ivan Amato, *Pushing the Horizon: Seventy-Five Years of High Stakes Science and Technology at the Naval Research Laboratory* (Washington, D.C.: Naval Research Laboratory, 1998), 141–42.

including the University of Virginia ($13,000), Columbia University ($30,000), and the Carnegie Institution ($3,500).[107]

NRL contracts with private laboratories focused on the need to encourage more efficient and effective methods of uranium enrichment, the most promising of which Gunn judged to be the liquid thermal diffusion process developed by Carnegie's Philip Abelson.[108] While it would initially be passed over by the Manhattan Project as a contender for separating bomb quantities of Uranium-235, Abelson's liquid thermal diffusion method remained throughout the war the NRL's top choice for the enrichment of sufficient U-235 to serve as fuel for ship propulsion, and as a means to retain a Navy foothold in the atomic energy arena. Ultimately, when it became clear that the so-called Abelson-Gunn process stood to speed up considerably the enrichment timeline at the Manhattan Project facility at Oak Ridge, whose production of bomb-grade uranium was beginning to lag behind schedule, the Army constructed a liquid diffusion plant at Oak Ridge in the summer of 1944 to accelerate the enrichment of fissile material in preparation for the first atomic bombs.[109]

The 11th hour collaboration did not immediately produce any wider opening of the door that separated the Navy from the Manhattan Project's wartime work on atomic energy. Rather, as with many objects of postwar interest, the fate of atomic energy R&D would be decided by committee. In 1944, the director of the Manhattan Project, Major General Leslie R. Groves, formed a committee under the chairmanship of Richard Tolman, a physicist on the general's staff and a former NDRC

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[107] Ibid., 143.

[108] Abelson soon thereafter became an official employee of NRL in July 1941. Ibid., 144.

[109] Richard G. Hewlett and Francis Duncan, *Nuclear Navy, 1946-1962* (Chicago: University of Chicago Press, 1974), 20–21.

vice-chairman. In deciding the composition of the body, Groves permitted the Navy to appoint two officers to serve as members of the Tolman group. As head of the Bureau of Ships (BuShips), Rear Admiral Edward Cochrane exercised authority over the selections, choosing his deputy Rear Admiral Earle Mills and the bureau shipbuilding division's chief of research and standards Captain Thorvald Solberg.[110] Both Mills and Solberg were graduates of the Naval Academy and Columbia University, held advanced engineering degrees, and favored the continuation of exploratory research on the possibility of naval nuclear propulsion. In support of this objective, in the spring of 1945 Mills himself sent an appendix to Tolman to be included in the committee's final report, detailing the advantages of nuclear propulsion for the Navy as a way of underscoring the report's recommendation that the Navy's nuclear power work be allowed to go forward.[111]

Crucially, while Mills, Solberg, and Cochrane supported the development of naval nuclear power, they were also of the mind that such a feat would require a great deal of time and patience. Both the scarcity of available fissile material stock – given the priority placed on weapons production – as well as the stark organizational realities imposed by the rapid postwar demobilization of the fleet convinced top Navy leaders (particularly those in BuShips) that a holistic postwar program for the service as a whole would be necessary to stave off further blows to morale.[112] Formulating such a program meant restraining the enthusiasm of any one faction of partisans seeking to lock down political support for their favored areas of investment, particularly those which threatened the funding

[110] Ibid., 22.
[111] Ibid.
[112] Ibid., 23.

stability of other established priorities of the Navy Department. The pursuit of naval nuclear propulsion constituted exactly the type of ambitious, high-risk technological endeavor that provoked widespread fears among the admiralty regarding the prospect of congress taking a fine-tooth comb to future Navy budgets.

The earliest proponents of naval nuclear power were dogged in their campaign to bring the Navy fully into the atomic age. Where Cochrane and Mills saw atomic energy as only one of several options for implementing the planned overhaul and redesign of the fleet, figures like Bowen, Gunn, and Abelson considered nuclear propulsion to be an overriding priority for the service and the next generation of Navy ships. Attempting to break through what they saw as BuShips' inexplicable postwar inertia with regard to standing up an independent Navy program of atomic energy development, Abelson and two other scientists at NRL published a report in March 1946 proposing the construction of a nuclear powered submarine within a span of two years.[113]

Notably, while the report lacked many technical specifications for the proposed submarine apart from the reactor, it did advance the notion that the German Type XXI hull design, if retrofitted with a nuclear power source, promised to yield a weapon of unprecedented speed and underwater endurance. This proposed fusion of state-of-the-art submarine design principles with the as yet untested affordances of nuclear propulsion constituted one of the earliest and most durable features of arguments forwarded by the Navy's pro-nuclear officers and civilian scientists. Such rationales served to give concrete form and a new level of technical feasibility to the long-held ideal of the "true

[113] Ibid., 27.

submarine" – that is, a submarine with the capacity to operate submerged continuously, such that its detection and destruction by enemy ASW is rendered far more difficult. As will become increasingly clear, this aspiration to field the "true submarine," and its contemporary articulation as a nuclear-powered vessel with a hydrodynamic hull, over time welded together the R&D fortunes of naval nuclear propulsion and ASW, periodically to the chagrin of the distinct communities behind each of these domains of technical activity.

Unsurprisingly, Abelson's initiative failed to dredge up additional support for a standalone Navy effort in the new field of atomic energy. Instead, the leaders of BuShips deferred to the suggestion of Major General Groves by assigning a small number of engineering officers to the Oak Ridge facility for training in nuclear technology. Mills, who succeeded Cochrane as Chief of BuShips in 1946, solicited the recommendations of his staff as to which officers should be detailed to Oak Ridge. Captain Albert G. Mumma, then chief of BuShips' machinery design division, impressed Mills with his list of names, which included a core group of officers with strong engineering credentials, each of whom had completed advanced degrees at MIT.[114] Mills quickly accepted all of Mumma's proposed personnel assignments, with the exception of his choice for the leader of the Oak Ridge group, Captain Harry Burris.

Recommended on the basis of his wartime work expediting the production of steam power plants for destroyer escorts, Burris was accustomed to navigating diplomatically the tensions that arose in the course of complex, operationally-oriented R&D schedules, whose component programs were

[114] Mumma's officer selections included Louis H. Roddis, Jr., James M. Dunford, Miles A. Libby, and Raymond H. Dick. The civilian personnel represented were Alfred Amorosi, George B. Emerson, and Everitt P. Blizzard.

often in competition for limited resources and personnel. In a decision as controversial as it proved fateful, Mills chose to replace Burris with Captain Hyman G. Rickover, the notorious wartime chief of BuShips' electrical section. With an obsessively detail-oriented approach to program management that could hardly have diverged further from that of Captain Burris, Hyman Rickover had over the years earned a service-wide reputation for his ruthlessly hands-on brand of technical supervision. Despite the long line of enemies he had made in this way over the course of his long career, Rickover struck Mills as the officer best qualified to arrive at the fastest, firmest fix on what exactly the prospect of nuclear power could mean for the Navy. Partly for the same reason, Mumma strongly opposed the selection, fearing that Rickover's uncompromising style of micromanagement (and a tendency to steamroll all manner of obstacles without regard for the consequences) would place an undue strain on BuShips' extensive array of non-nuclear commitments. Nevertheless, Mills as chief of the bureau stood by his pick, who would soon live up to both his and Mumma's expectations.

Rickover wasted no time in his new role as the ranking naval officer at Oak Ridge. Immediately prior to his arrival in May 1946, Rickover had taken a detour to Pittsburgh to pay a visit to the new president of the Westinghouse Electric Corporation, Gwilym A. Price. Having quickly persuaded Price of the commercial promise of atomic energy for both military and civilian power production, Rickover secured the early commitment of an important industry partner for the Navy. Over the subsequent year spent learning the ins and outs of nuclear engineering and reactor physics at the Monsanto-operated Clinton Laboratories in Oak Ridge, Rickover continued to cultivate an extensive array of contacts among private industry representatives sent to assess the commercial opportunities of developing atomic power.

In addition to the task of drawing together the necessary base of industrial support, Rickover and the rest of the Oak Ridge group found themselves responding to developments originating within the Navy on the matter of what priority (and what form) nuclear power should take in the context of the postwar fleet. Throughout the fall of 1946, the Submarine Officers' Conference held a series of meetings on the subject of advanced submarine design and methods of ASW. Their ultimate verdict held that antisubmarine techniques would inevitably improve to the point where "the snorkelling submarine becomes readily detectable, [and] nothing short of a deep-running true submarine will be acceptable."[115] At such a juncture, these officers argued, nuclear-powered submarines would become an operational necessity.

Following up on these conclusions, on January 9, 1946, submarine officers proposed a far-reaching overhaul of the Navy's existing fleet of submarines, including the development of new, more efficient diesel engines, sophisticated closed-cycle alternatives to air-breathing systems, and naval reactors capable of offering unlimited underwater endurance and high speeds while submerged. The very next day, the Chief Naval Operations Admiral Chester Nimitz, himself a submariner, approved the full list of recommendations and passed them down as directives to be implemented by BuShips. The reluctance of the bureau's leadership notwithstanding, the Oak Ridge group took note of the decision as a signal that the submarine might soon present the ideal platform to which to hitch the fortunes of the first naval nuclear reactor. Once again, the lure of the "true submarine" brought into

[115] Hewlett and Duncan, *Nuclear Navy,* 41.

yet closer alignment the technopolitical interests of specialists from the fields of ASW, advanced submarine design, and naval nuclear propulsion.

Significantly, the process of constructing this network took place alongside the sweeping changes that accompanied the reorganization of the military and its traditional roles and responsibilities. Most relevant to the work of the Navy's Oak Ridge group was the handover of control over fissile materials and atomic energy production from the Manhattan Engineering District to the newly established and civilian-led Atomic Energy Commission (AEC) in January 1947. If relations with the Army's secretive wartime organization proved difficult, the working dynamic that evolved between the Navy and the AEC was fraught at the best of times, and riven by mutual suspicions and personal animosities at the worst. (And in the early years of nuclear power development, it was always simultaneously the best of times and the worst of times.) At a basic level, the priorities of each organization ran so far afoul of those of the other that Rickover often went about his work on naval nuclear propulsion in ways that undermined the existing plans and decision-making structures of the AEC.

One noteworthy example of this pattern took place in November 1947, at a meeting of the AEC's newly formed reactor development group. Rickover had secured an audience with the influential body for his boss Admiral Mills, who briefed the members of the reactor group at length about the sources of Navy interest in nuclear propulsion. Having eventually been himself persuaded by Rickover to favor the immediate development of atomic energy as the ideal means of powering the Navy's ships, Mills' testimony centered around the strategic importance of developing the "true" submarine and the reasons why he considered the only possible means to this end to be nuclear power.

The reactor group, composed of more engineers than scientists (another artifact of Rickover's maneuvering), reacted favorably to Mills' presentation, and quickly approved a naval reactor study to be completed at Oak Ridge within the coming months.[116]

Given the AEC's preoccupation at the time with maintaining plutonium production levels at its Hanford site, and centralizing its R&D efforts on reactor engineering at Argonne, the reactor development group's decision to encourage AEC personnel to participate in a Navy study likely could not have been replicated under any other circumstances. As it was, Clinton scientists and engineers had already (albeit quietly) begun studies earlier that fall to evaluate the pressurized water design first proposed by Alvin Weinberg the previous year and favored by Rickover as a promising candidate for a workable naval reactor. Having been encouraged (by Rickover) to shift their attention from the laboratory's official project of investigating the properties of the Daniels reactor to the pressurized water design, Clinton's reactor division was well-positioned to take on more formal studies come November.

By the end of the month, Rickover had fully circumnavigated the AEC and the newly constituted National Military Establishment in his quest to secure the future of naval nuclear propulsion. Over a matter of weeks, he obtained the necessary endorsements to present the CNO with a draft letter for his approval and signature to send to the Secretary of the Navy, John L. Sullivan. The letter took the form of a proposal recommending the development by the mid-1950s of a nuclear-powered submarine with unlimited endurance at high speed capable of delivering nuclear-tipped

[116] Ibid., 56.

guided missiles at a range of 500 miles.[117] Nimitz quickly signed the letter and sent it on to the Secretary, who in turn also gave his support, forwarding the proposed program to the new Secretary of Defense James Forrestal as well as the Research and Development Board. Thus, the means by which figures like Rickover secured the political mandate to proceed with the development of a naval reactor ultimately served to align the ends of their technopolitical projects with those of undersea warfare specialists preoccupied with the problem of ASW in the atomic age.

The character and degree of interdependence that grew up between these various R&D channels over the course of the late 1940s was a function of the particular form of opposition each faced within the highly competitive context of the wider Navy Department during that period. When the AEC attempted to stall the process of working out an organizational arrangement with BuShips for the approved nuclear submarine development, Mills and Rickover decided to go on the offensive, and their battleground of choice was none other than the Undersea Warfare Symposium held on April 2, 1948. As he had been invited to give his own prepared remarks, Mills took the opportunity to deliver a speech (written by Rickover) pointedly calling out AEC Commissioner Lewis Strauss and his colleagues at the head of the organization for neglecting to recognize the development of the nuclear-powered submarine as an official project of the highest priority, as well as for failing to resolve with the Navy standing disputes over the organization of their joint venture. In light of the fact that Strauss and his fellow commissioners were all in the audience of approximately 700 people, Mills' statement left a large impression on those at the conference and did serve to shake loose a response from the AEC.[118]

[117] Ibid., 58.

[118] Ibid., 65.

The backdrop of the Undersea Warfare Symposium is significant for at least two reasons. First, the preceding spring had witnessed a number of developments which raised the profile of advanced submarine R&D, including a stark assessment by the Commander of the Pacific Fleet Raymond A. Spruance. On February 11, Spruance gave a speech in which he said the following:

> The new submarine with high submerged speed and great underwater endurance is probably the greatest threat that exists today to safe use of the sea. Until a solution is reached to the problem of how to destroy this submarine, and until the forces are made available for this work, we shall be in a poor position to operate our armed forces overseas against an enemy who has a large fleet of them and knows how to use them efficiently.[119]

Combined with widely circulated reports that claimed the Soviet Union may have taken as many as twenty Type XXI U-boat prototypes, and many German ship designers besides, the successful conversion of many U.S. fleet submarines along these lines only served to harden the assumptions of the undersea warfare community regarding the inevitability of equivalent developments in Soviet forces. The growing belief in the existential threat to the Navy posed by Soviet submarines mirrored – and by the same token, belied – the reality of existing U.S. efforts to capitalize on its own access to advanced German submarine technology. By the time the Undersea Warfare Symposium convened in April 1948, the need for a high-endurance, high-speed submarine was treated as a matter of course among this community, a fact which placed the AEC in the untenable position of appearing to delay a program of the highest strategic and tactical significance.

Second, on the ASW front, the Navy's Operational Development Force painted a bleak picture in a report to the service's General Board, stating that "the tactical characteristics of the

[119] Ibid., 73.

medium speed, deep diving snorkel equipped submarine have virtually nullified the effectiveness of most of our World War II ASW procedures, tactics, and doctrines."[120] In other words, the report claimed that not only were submarines bound to improve beyond the capabilities of the Type XXI, but the current generation of Type XXI variants already outmatched the state-of-the-art in ASW techniques and instrumentation. The resulting sense that the ASW problem constituted an acute case of technological lag in urgent need of redress lent an almost desperate quality to undersea warfare specialists' claims that only the "true submarine" could serve as the ideal ASW platform. Thus, from the perspective of both contemporary pro-submarine and anti-submarine efforts, the nuclear-powered submarine had no shortage of friends in undersea warfare circles.

Picking up on the work of some of the most influential of those friends, the CUW panel on the hydrodynamics of submerged bodies – convened the summer following Mills' speech before the Undersea Warfare Symposium – brought together scientists and engineers from the Navy's David Taylor Model Basin (DTMB), Brooklyn Polytechnic Institute, Portsmouth Naval Yard, and Woods Hole for the purpose of designing an advanced experimental submarine capable of submerged speeds in excess of twenty knots.[121] Captain Mumma, then DTMB director, took the possibly unprecedented step of giving the civilian experts complete autonomy over all aspects of R&D associated with the program. The most important component, the ship's hull, necessitated the development of novel computational techniques for accurate modeling of cylindrical pressure hulls and framing needed for construction. Dampening the noise profile of the high-speed sub to be built required undertaking

[120] Ibid.

[121] Weir, *Forged in War*, 140.

investigations of hull vibrations, machinery noise, water flow around the hull, and noise from passive sensors to adopt necessary refinements.[122] Centered around the DTMB Hydrodynamics section under the direction of Dr. Louis Landweber, the work of refining what would ultimately become the Series 58 hull form according to a teardrop-shaped body-of-revolution design represented one of the most critical postwar developments in advanced submarine design.

The *USS Albacore* launched on August 1, 1953, and successfully completed a year of shakedown trials by February 1955, in the process proving the stability and maneuverability of the hydrodynamic hull form under operational conditions and setting the stage for future generations of nuclear-powered subs. The design superintendent of the Portsmouth Naval Yard Commander Donald Kern summarized the significance of the *Albacore* in the following terms:

> Albacore's value to the Navy, aside from showing that the Series 58 hull form worked, was more in telling us what didn't work [about existing design practice]. It told us what not to do far more than it told what to do.[123]

As one might expect, the matter of what not to do was a controversial one. Many of the *Albacore*'s novel design features ruffled feathers throughout BuShips, and several found themselves overruled for straying too far from accepted design practice.[124] Nevertheless, the fact of the *Albacore* itself represented a significant departure from accepted practice. The development of an experimental prototype as large-scale as the *Albacore* was an early indicator of the creative license that civilian

[122] Ibid.

[123] Ibid., 146.

[124] Ibid., 141.

scientists, such as those who served on the CUW, would be empowered to take in the age of atomic energy and the advanced submarine.

Slightly more than a month prior to the *Albacore* heading out of drydock, the Submarine Thermal Reactor (STR) Mark I – a land-based prototype of the reactor that would power the *Nautilus* – completed its first test run totaling 100 hours of continuous operation, a feat which simulated a transatlantic voyage.[125] The *Albacore*'s speed, which comfortably surpassed 20 knots submerged, and the unprecedented endurance of the *Nautilus*, which went to sea on January 17, 1955, and went on further to break a slew of performance records, appeared to many as heralding a revolution in the conduct of naval warfare.[126]

Of course, the simultaneity of the *Albacore* and *Nautilus* projects was no accident. NRL had long proposed pursuing the concurrent development of advanced hull forms and naval reactor technology. While it is unclear to what extent NRL personnel foresaw the ways in which these domains of R&D would interact with each other, in ways that were both mutually reinforcing politically and routinely destabilizing technologically, what is more clear is the precedent this approach set for the pursuit of naval nuclear applications alongside the means of designing (and detecting) faster, quieter, deeper-running submarines. As will become ever more apparent as we track the evolution of naval R&D through the first half of the Cold War, the near-lockstep synchronicity between developments in submarine design and ASW over time will act to increase the nebulousness of the distinction between measure and countermeasure, with significant implications for the debates

[125] Ibid., 168.

[126] Hewlett and Duncan, *The Nuclear Navy*, 220.

over doctrine and force structure that would dominate the late 1950s and the years leading up to the Strategic Arms Limitation Talks. As we will see in the following chapter, this convergence progressed hand in hand with the melding of survivability and counterforce rationales in the context of contemporary ballistic missile developments.

Conclusion

This chapter began from the flashpoint of 1949, before probing the years that preceded and followed that seemingly fateful moment of defeat for the Navy. The spectacle of the admirals' revolt lends itself to a kind of historical account that addresses only the overexposed elements of a historical picture. Shifting the spotlight of analysis away from these elements toward the more obscure corners of the scene allows us to be clearer judges of which elements we might say properly belong to the background and which instead to the foreground. I take the "problems of overseas transport" to be an instructive frame through which to understand the animating challenges that structured much of the internal activity of the Navy throughout World War II and the decade following.

As a lens, the problems of overseas transport allows us to consider side-by-side the World War II experience of vulnerability at sea; the postwar prospect of technological surprise in advanced submarine design; the enduring threat perception, sustained by cold war, regarding Soviet ASW; the Air Force's unflagging determination to divest the Navy of its air assets; as well as the technical, organizational, and tactical difficulties of pursuing the "true submarine." Across all of the time periods during which any one or more of these concerns prevailed among Navy officers, the central fact of the

problem no matter its manifestation remained always the perceived vulnerability of surface ships to submarines. For Navy personnel, such a situation soon begged the question: if the vulnerability of surface craft constituted a given of the wartime and postwar eras, what was the *solution* for overseas transport?

Of course, while no single solution ever put entirely to bed the internal Navy debate over this question, a particular set of responses did emerge that sought to confine the threat posed by advanced submarines more and more strictly to the domain of undersea warfare. The lobbying of civilian ocean scientists for broader Navy investment in this domain, the increasing strategic and tactical significance attached to the submarine platform, and the determined drive to develop submarines that never had to surface at all constituted instances in which the imagined theater of future war was drawn further and further from the ocean's surface. Thus, some of the most visible technopolitical affordances contained within such responses centered around the preservation of the Navy's surface forces, not only in the sense of their material protection but also in terms of insulating such platforms from political attacks. Less visibly, but potentially with more far-reaching consequences, the very murkiness of the categories involved in undersea warfare – that is, the basic indistinguishability of a more advanced submarine from a more effective ASW platform – functioned as a de facto engine driving the continuous elaboration of ever more sophisticated means of hiding one's own submarines and seeking the enemy's.

III: Getting to Polaris: How a Moving Target Became the Navy's North Star

> "[The Polaris program] had to have a tremendous amount of support. It couldn't be done by fear. You had to get people interested in it. So what we needed was a man who could get other people to do a hell of a lot of work and had an idea of...who could get things done without creating a fight and without going around demanding things. We've had enough of — like, Rickover, for example...[H]e had to be a hard worker, he had to be persuasive, he had to be a salesman...It should be an aviator, because [Polaris] was going to displace an aviation mission. Also there was a large number of aviation problems involved in building such a missile. Finally, I selected Red Raborn, which turned out to be my big contribution"[127]
>
> – Arleigh Burke, 1972

Introduction

Long before Arleigh Burke appointed him to lead the Navy's fleet ballistic missile program, William "Red" Raborn had become experienced at handling unconventional developments. As a naval aviator during the late interwar years, Raborn turned heads within the Navy when he took it upon himself to retrofit surface-ship-based anti-submarine torpedoes with makeshift fins, such that they could be carried on the wings of patrol planes with their own specially modified bomb racks. Though he received a "blistering" response from the Bureau of Ordnance for exceeding his authority — being told in no uncertain terms that "such things were not a matter for the fleet to experiment with" — Raborn and his collaborators went further, enlisting the help of metalsmiths in San Diego to reinforce

[127] Admiral Arleigh Burke, interview by John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 19 September 1972, 10-11.

the bomb racks of patrol planes and enabling them to carry 300-pound depth bombs for use against surface ships.[128] When his patrol wing was deployed to Pearl Harbor (22 days before the outbreak of World War II), his commanding officer took a different stance altogether on the unsanctioned adaptations, considering them indispensable and immediately ordering a crash program of manufacture for bomb racks to carry torpedoes and depth bombs on patrol planes.

Ironically, or perhaps as a result, after the war Raborn was sent to the Bureau of Ordnance as assistant to the chief for R&D related to aviation, including work on ship-based guided missiles. While serving in this role, he soon came to the attention of Navy leaders, particularly one Arleigh Burke, as a prime candidate for the job of leading the Navy effort to develop the first sea-based ballistic missile.[129] When he was ultimately tapped for the position of Director of Special Projects, Raborn more than lived up to Burke's hopes of finding a manager capable of heading a large-scale, still-unpopular development without the arm-twisting and infighting that was proving to be a feature rather than a bug of Hyman Rickover's contemporary campaign to nuclearize the Navy. So starkly did Raborn's management style depart from the Rickover model that in an interview nearly twenty years later he spoke of the thousands of workers that contributed to the construction of the Polaris missile as "his tigers" and a part of "the military-industrial family," and credited in part his evangelical Baptist upbringing for the intense fervor and dedication he was able to whip up through his speeches on many a factory floor.[130]

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[128] Vice Admiral William F. Raborn, Interview by John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 15 September 1972, 4-6.

[129] Ibid.

[130] Ibid., 52-53.

Raborn's interview, conducted by John T. Mason in the fall of 1972, took place mere months after the signing of the first bilateral arms control treaties between the United States and the Soviet Union. However, the U.S. Naval Institute did not publish the interview — part of an oral history series on the development of the Polaris missile — until fully a decade later. The reminisces of Polaris program leaders were notable for their pointed comparisons to the more regulated contemporary practices of systems management within the military. Carlton Shugg, who had left his postwar role as Deputy General Manager of the Atomic Energy Commission (AEC) for a position at General Dynamics' Electric Boat Division (the primary private shipbuilder for the FBM submarines), recalled that he told his legal counsel, perhaps half-jokingly, that "I expected to be investigated, I expected to be tried, if you will, and that I wasn't trying to keep out of jail but his job was to advise which of several possible alternatives would get me the shortest sentence!"[131] In a similar vein, Jack Dunlap, the Polaris team's resident expert on what he called "human engineering," noted that many went to work well before they ever received official contracts.[132]

The timing of this oral history's publication is significant because the Navy of the early 1980s was still embroiled in a years-long legal battle with General Dynamics over what was at the time the largest cost-overrun scandal in the company's history.[133] Over twenty years out from its last public relations victory, and with public confidence in Navy management at an all-time-low, the publication

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[131] Carlton Shugg, Interview by John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 16 November 1973, 7.

[132] Jack Dunlap, Interview by John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 2 October 1972, 20.

[133] For a detailed account of the controversy and its roots in the politics of submarine R&D, see Patrick Tyler, *Running Critical: The Silent War, Rickover, and General Dynamics*, (New York: Harper & Row, 1986).

of the Polaris oral history collection recalled a time when, despite legal restrictions being sparse and easily brushed aside, the Navy had been able to produce a finished weapon on time and under budget. Thus, despite the even greater lack of transparency that characterized weapons management during the Polaris years, the demonstrated concern of SPO personnel for their program's optics betrayed an acute awareness of the many obstacles that threatened the Polaris development effort even in the absence of high-profile revelations of corporate and federal misconduct. Overcoming those obstacles required Polaris designers to make continuous adjustments to the terms in which they described their program's overall objective.

This chapter continues to trace the evolution of intra-Navy responses to the postwar problem of vulnerability over the course of the 1950s, particularly as they related to and were reimagined by the drive to develop a sea-launched ballistic missile. I argue that vulnerability, as it pertained to the technical, operational, and political fortunes of particular weapons systems, presented both a blessing and a curse for Navy planners even as it motivated the development of that period's two most significant naval initiatives – the nuclear-powered submarine and the submarine-launched ballistic missile. Focusing on R&D efforts in anti-submarine warfare (ASW) and submarine-launched ballistic missiles (SLBM), this chapter takes up the question of how the individuals responsible for these programs shaped ideas about vulnerability and its obverse, survivability, at a time when these terms remained functionally undefined and ungoverned in an increasingly competitive defense spending environment.

The following sections thus trace the processes by which a relatively small network of individuals engaged in highly uncertain undertakings in the world of naval research and development

cemented a service-wide reshuffling of Navy missions, programs, and priorities, with far-reaching implications for the shape and direction of nuclear force planning in the Navy and the U.S. national military establishment at large. In organizing this chapter almost exclusively around the work of Navy officers and their collaborators in industry and academia, I further make the case that it is impossible to understand the emergence of the Navy's fleet ballistic missile (FBM) program and its early incorporation of a multiple-warhead reentry vehicle without first placing this development in the context of this community's long-running debates about the problem of vulnerability and the technopolitical affordances offered by various formulations thereof.

As in the previous chapter, I use the term technopolitical affordances to refer to the various advantages conferred by a particular way of framing the functions and capabilities of a technological system vis-a-vis a specific audience. That chapter showed that early postwar campaigns to characterize submarines as simultaneously defensive (that is, putatively invulnerable) and offensive (that is, putatively vulnerable) platforms provided a durable rationale for maintaining large investments in *both* advanced submarine design as well as ASW. In this chapter, I connect the work of undersea warfare specialists and their construction of a measure-countermeasure dialectic to the work of SPO personnel engaged in developing the fleet ballistic missile and its successors. This chapter locates thus explores the consequences of the successes encountered by the ASW and larger submarine community, and points out the novel technopolitical affordances offered by frames of vulnerability in the ballistic missile context, where missile designers leveraged claims of improved Soviet ASW to lobby for larger, longer-range follow-on missile systems.

As we have seen, nowhere was this concern about vulnerability more central than in early post-WWII efforts to develop more sophisticated and comprehensive techniques in submarine detection and tracking, a set of technological pursuits that – by virtue of its being almost by definition premised on the contemporary state-of-the-art in submarine stealth technology – simultaneously stimulated demand for its own countermeasures. Those engaged in such ASW-related research thus widely marketed this mission within the Navy as a robust source of new requirements and even a means of life support for a range of weapons systems threatened with obsolescence in light of the growing dependence on nuclear weapons within national military policy. With the ASW mission ascendant, the 1950s witnessed a series of important milestones for the naval R&D community that served to entrench practices of requirement-setting based on contemporary ASW capabilities — practices which went on to define performance benchmarks for generations of fleet ballistic missiles.

In other words, in addition to providing the entire spectrum of existing Navy platforms a renewed operational justification — including carrier-based aircraft, destroyers and other surface vessels, and indeed, submarines — the undersea warfare community presented the earliest and most consistent base of support for the FBM program. Moreover, prioritizing the ASW mission as a justification of future forces gave Navy officers a compelling practical argument for maintaining operational control over their ballistic missile forces once deployed even in the midst of an increasingly centralized nuclear war planning apparatus. Most importantly, R&D advocates effectively wielded the specter of Soviet ASW in ways that made this work appear indispensable in light of the development of the service's first independent ballistic missile, the Polaris.

Generating this tension between the vulnerability of the nuclear-powered submarine promised by cutting-edge ASW and the invulnerability of that platform claimed by Polaris proponents proved productive for R&D advocates in both areas, not only by motivating follow-on generations of the FBM and a range of ASW platforms, but further by cultivating among program officials and their collaborators an abiding interest in developing increasingly flexible benchmarks for survivability. The primary goal of this chapter is thus to chart the management of this tension by technical communities and the role that this tension played in blurring the previously bright line that had separated countervalue and counterforce targeting in Navy doctrine.

To that end, in the next section I provide an account of how a pro-SLBM consensus formed within the ASW community that still comprised a relatively small fraction of the uniformed Navy, though a much larger segment of those in affiliated laboratories in industry and academia. In the penultimate section, I turn to the Special Projects Office (SPO), home of the FBM program, and a close analysis of its steering group meetings in order to show how program officials conceived of the ASW problem, both as a framework for benchmarking system performance as well as a means of generating political capital among various quarters of the Navy hierarchy. In the final section, I lay out the ways in which Polaris officials dynamically managed perceptions of the FBM program and the precise operational role it was intended to fulfill. I conclude by showing that SPO personnel and their colleagues at contracting organizations strove to minimize the political space for opposition to the Polaris weapon by designing it to be maximally flexible, both in terms of its operational characteristics and its political viability, a practice that led ultimately to the incorporation of a multiple warhead reentry body on the Polaris A3.

The submarine strikes back: Project NOBSKA and the FBM

Prior to 1955, Navy-sponsored forays in the realm of missile technology had been confined to short-range guided rockets. This situation changed, however, when in February of that year the Technological Capabilities Panel of the President's Science Advisory Committee (better known as the Killian Committee) submitted its report to Eisenhower evaluating American technological readiness to withstand a surprise nuclear attack by the Soviet Union. The report's central conclusion – that both the country's civilian population as well as its existing strategic arsenal remained unacceptably vulnerable to a Soviet first strike – laid the bedrock for an ambitious program of renewed federal investment in military R&D. Among the specific initiatives formally endorsed by the Killian Committee were two intermediate-range ballistic missile programs, both of which were to be pursued as a matter of highest national priority and capable of delivering one megaton warheads at ranges on the order of 1500 nautical miles.[134] Given its prior work in this area, the Air Force eventually took the lead in managing the first of these IRBM developments, with the Army being given initial jurisdiction over the second.

In the months leading up to the Killian report's publication, Commander Robert Freitag, who at the time directed the Surface-Launch Missile Branch of the Bureau of Aeronautics (BuAer), had been trying unsuccessfully, alongside the Chief Scientist of BuAer's Research Division, to secure

[134] *Foreign Relations of the United States,* 1955–1957, National Security Policy, Volume XIX, Document 9.

approval for a ballistic missile program from the Office of the CNO.[135] Having gotten nowhere in their attempts to drum up support within their own service, where the consensus remained that sea-launched ballistic missiles would only invite another fruitless turf war with the Air Force, Freitag and Hyatt set their sights instead on influencing the ongoing work of the Killian Committee toward a favorable verdict on the need for a sea-based ballistic missile capability. While they achieved this particular tactical objective by passing along BuAer studies of various SLBM concepts to the Killian Committee's Navy liaison Captain Peter Aurand, it took a fair amount of maneuvering before the legitimacy bestowed by the Killian report's endorsement of a sea-based ballistic missile concept could be translated into a Navy program.

Nevertheless, the approving nod from the administration's top scientists brought on new converts from BuAer, including the head of the Guided Missile Division Captain Alfred Metsger and Bureau Chief Rear Admiral James S. Russell.[136] Facing continued and determined opposition from the CNO's planning staff, the growing ballistic missile lobby within BuAer throughout the spring of 1955 increasingly sought out the support of the civilian Navy Secretariat, much to the chagrin of senior officers. While they enjoyed some success in that quarter, divergent technical assessments offered by the various materiel bureaus and naval laboratories sowed doubt as to the feasibility of a sea-based ballistic missile, nearly prompting DOD to place the Air Force in charge of all ballistic missile development. Ultimately, what broke the bureaucratic impasse within the Navy was the appointment of a new Chief of Naval Operations, Admiral Arleigh Burke, in August 1955. Within a week of taking

[135] Harvey M. Sapolsky, *Polaris System Development* (Cambridge: Harvard University Press, 1971), 18.
[136] Ibid., 19.

office, Burke threw his support behind the pursuit of a Fleet Ballistic Missile (FBM) program, and proceeded to broker a temporary truce among the various bureau chiefs by bracketing the budgetary and jurisdictional questions inflaming hostilities to the program.[137]

By early September, however, the Eisenhower administration had already decided to cap the number of ballistic missile programs that would be funded at four, three of which had been assigned to the Air Force and the last to the Army. After being advised to join forces with one of the other services to develop a sea-launched variant of either IRBM, the Navy soon partnered with the Army on its Jupiter development (after first getting turned down by the Air Force to take part in its Thor IRBM program).[138] Within the Navy, on the other hand, the politics of getting the still unpopular initiative off the ground were more complicated to navigate. For Admiral Burke, giving primary jurisdiction of the FBM to any single bureau risked earning the program many more enemies than friends while it was still relatively vulnerable.[139] The solution was to establish a new, independent organization for the job, which the Navy Secretariat founded a little over a week after DOD formally authorized its partnership with the Army in November 1955. The Special Projects Office (SPO) at that point became the official home within the Navy of all FBM-related initiatives. Treading the fine line between the rival Bureaus of Aeronautics and Ordnance, Admiral Burke appointed Admiral William F. Raborn – an aviator who had also served in BuOrd overseeing guided missile R&D – as SPO's first director.[140]

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[137] Admiral Arleigh Burke, interview by John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 19 September 1972.

[138] Sapolsky, *Polaris System Development*, 22-23.

[139] Admiral Arleigh Burke, interview by John T. Mason.

[140] Ibid.

The Army-Navy collaboration showed signs of strain from the outset. The 58-foot-long, liquid-fuel design presented Navy engineers with a seemingly intractable weapon for shipboard use, as the pitching, weather-prone conditions that would be found on any naval carrier capable of serving as a launch platform for a Jupiter-sized missile were practically irreconcilable with the contemporary stringent operational and environmental demands for safely storing and handling liquid rocket fuel. SPO personnel were candid with their Army counterparts about their strong preference for a solid-fuel design, something which Army scientists had dismissed early on as idle yearning.[141]

In fact, there was very little that could be called idle about SPO's efforts in the realm of solid-fuel research. Having been given broad powers by Admiral Burke to recruit any Navy officer or civilian of his choosing to the FBM effort, Raborn had stacked SPO with the Navy's leading experts on solid-fuel rockets, who quickly set about demonstrating that a sea-launched liquid-fueled missile "would make an internal combustion engine out of the whole submarine."[142] Once they had proven (at this point, only to themselves) that liquid-fuel designs would be disastrous for shipboard or submarine use, by January 1956 Navy officials presented the Defense Department with something of a fait accompli by soliciting technical advice on solid-fuel ballistic missile concepts from the Aerojet-General Corporation and the newly established Lockheed Missile and Space Division. The resulting design, dubbed the Jupiter S, used a cluster of six solid-fueled rockets for its first stage alone, with one

[141] One prominent Army rocket engineer reportedly quipped, in light of the relatively low specific-impulse of contemporary solid fuels, that the furthest east the Navy could hope to get with a solid fuel design was Switzerland. See Sapolsky*, Polaris System Development,* 24.

[142] Vice Admiral William F. Raborn, interview with John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 15 September 1972.

additional rocket for its second stage, to produce the needed range performance, and soon marshaled the support of the Navy Secretariat. Despite initial skepticism, the Ballistic Missile Committee of the Office of the Secretary of Defense (OSDBMC) in April 1956 approved $850,000 in start-up funds, soon supplemented by the Navy, for Jupiter S system studies, which it approved as a "backup program" for the original Jupiter IRBM.

While the efforts of SPO personnel had in short order brought solid propellants more firmly into the realm of official consideration, they remained less than enthusiastic about a missile design that was almost as ungainly as its predecessor (the Jupiter-S still stood at 44 feet tall and weighed 160,000 pounds). The situation would change drastically over the second half of 1956, beginning with the latest ONR-sponsored summer study to tackle, once again, the problem of anti-submarine warfare. This time around, it had been the CNO, Admiral Burke, who approached the National Academy of Sciences Committee on Undersea Warfare to solicit analysis and recommendations in the area of ASW weapons.

Registering nearly twice the number of full-time members as participated in the Hartwell study, Project NOBSKA, as this new effort came to be called, unlike its predecessor drew fully one-third of its total personnel directly from the operational and technical ranks of the Navy itself. At the request of the CNO, Project NOBSKA took as its object an analysis of what it termed "The Implications of Advanced Design on Undersea Warfare," a reference, in part, to the previous January's operational debut of the world's first nuclear-powered submarine, the *USS Nautilus*.

I say only in part because, as it turned out, Project NOBSKA saw few, if any, fixed quantities in the area of "advanced design" relevant to undersea warfare, a principle which members held applied even to the novel fact of nuclear propulsion. In fact, on this point they went so far as to state that:

> The reactor art is also likely to continue to move ahead rapidly, but it should be emphasized that until nuclear plants can be made quiet, they are not necessarily the optimum propulsion system for the true submarine. Any system of reasonable endurance that does not require air and that is really quiet could be a strong competitor.[143]

Nevertheless, NOBSKA members were not immune to the impressive performance record that the *Nautilus* continued to demonstrate throughout its first year on patrol.[144] What they called "the true submarine" – long considered the Holy Grail of ship design – by any estimation was a true game-changer for the ASW mission, which now had to contend with a platform whose Achilles' heel, the snorkel, had been eliminated. Coupled with contemporary developments in hull design which promised greater speed and stealth in future ships, nuclear propulsion, according to the members of Project NOBSKA, offered an opportunity to field a formidable and altogether new weapon system. They described the strategic and technological juncture at hand in the following terms:

> For the first time unlimited underwater endurance is possible, and the submarine's link to the surface has been cut. The essential qualities of the true submarine so successfully introduced in the NAUTILUS, combined with the latest weapons under development, have opened up new potentialities. To the traditional anti-shipping threat must now be added another of at least equal magnitude: submarine-launched missiles equipped with megaton warheads. Nor have we reached the summit in submarine development for the combination of the advanced reactor power plants with the hydrodynamic form of the ALBACORE hull, together with the

[143] Committee on Undersea Warfare, National Academy of Sciences, Project Nobska: The Implications of Advanced Design on Undersea Warfare, Final Report, Volume 1: Assumptions, Conclusions, and Recommendations, 6.
[144] "Significance of the Nautilus Polar Cruise," U.S. Naval Institute, May 1, 1958.

> systematic application of noise reduction techniques and the development of improved submarine weapons, promises an even more potent warfare system.[145]

While far from being ambivalent about this new development, the tone NOBSKA struck on what such a revised tactical landscape meant for the Navy was decidedly twofold. In a move which strongly recalled the spirit of the Hartwell report, the members of Project NOBSKA noted that:

> The chief question which we have asked ourselves is: how can our Navy most quickly prepare itself to deal with this very difficult and new ASW problem? As a corollary, we necessarily added the questions: how can our Navy best exploit similar offensive capabilities; and of what significance are they in the modern military scheme?[146]

Given such terms of reference, Project NOBSKA's analysis of its central object of study could not have escaped a certain irreducible complexity.[147] Through its framing of the advanced submarine as a platform that was simultaneously both measure and countermeasure, NOBSKA's recommendations effectively came in matter-antimatter pairs. For example, consider the following assessment of the projected threat posed by the ballistic missile carrying advanced submarine:

> Confronted with quiet submarines of long endurance, a sufficiently accurate means of navigation, and suitable weapons, a defense against shore bombardment by submarines becomes a huge problem. Even the partial defense of a long coastline requires a very large effort. Obviously, then, we should impose on the enemy the necessity of making this effort, and the more effective our system can be made the more of his resources will have to be consumed in purely defensive measures...

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[145] Committee on Undersea Warfare, National Academy of Sciences, Project Nobska: The Implications of Advanced Design on Undersea Warfare, Final Report, Volume 1: Assumptions, Conclusions, and Recommendations, 7.

[146] Ibid., 5

[147] Readers will perhaps recognize this term from quite a different historical context — that is, the evolution vs. intelligent design debates of the 1990s — where it was coined to refer to the creationist claim that certain biological systems could not have evolved from simpler ones, as the removal of any one component would cause the entire system to cease functioning. I use this term advisedly, to draw attention to the fact that had the NOBSKA report not defined its terms of reference so expansively, in such a way as to include both anti-submarine and pro-submarine R&D under its purview, the resulting recommendations would not have lent themselves to the establishment of a nearly self-sustaining measure-countermeasure dialectic.

> The effective submarine bent on a land assault mission presents the most difficult of all ASW problems. A highly effective defense of the U.S. against a determined surprise attack of this type appears to be extremely difficult and costly. These conditions argue strongly for the development of a similar U.S. attack capability as a deterrence against such attack.[148]

At the same time, however, NOBSKA insisted in no uncertain terms that "heavy investment in antisubmarine warfare capabilities is obligatory." It is important to point out that the context of this recommendation makes clear that NOBSKA members understood their mandate to be making as detailed a study of the weaknesses of advanced submarine designs as of their strengths. Thus, they did not limit themselves to simply proposing means by which the advanced submarine threat could be neutralized, despite this having been the original goal of the NOBSKA study. Rather, they placed equal emphasis on proposals to develop advanced submarines as in and of themselves a possibly more cost-effective means of ASW, on the supposition that such a weapon in the hands of the United States might provoke a relatively more costly Soviet initiative to defend against such a threat. What separates these recommendations from a straightforward pursuit of superiority is the ever-present frame of vulnerability. For the NOBSKA group, contemporary ASW techniques appeared less effective against the threat of the advanced submarine, but conversely, the advanced submarine could – and according to NOBSKA, should – also be rendered vulnerable to the threat of more sophisticated ASW. In both instances, the object becomes no longer a matter of evading enemy defenses, but instead becomes fixated on discovering the weaknesses in one's own defensive *and* offensive capabilities.

[148] Ibid., 34.

Given the circular logic of this approach to the problem of vulnerability, the problem itself reliably defied any stable definition. And as dependent as it necessarily remained on the prevailing state of the art, ASW could only become more imperative as work on advanced submarine design proceeded apace – as indeed NOBSKA members suggested it should. The breakneck pace of this dialogue could be made manageable, they maintained, through a focused effort at evolving more flexible military capabilities, the demand for which "can probably best be met technically through the exploitation of science and engineering to the building of both a spectrum of weapons systems and a variety of evaluated devices and techniques upon which the Navy may draw for the rapid design and fabrication of additional weapons systems."[149] Thus, Project NOBSKA drew on the legacy of the Hartwell study in more ways than one – not only by operationalizing the fusion of measure and countermeasure development, but also by appealing to the potential of this fusion to beget ever more flexible operational capabilities.

What exactly NOBSKA members meant by "flexibility" was perhaps even more significant in its implications for naval force structure than the term had been six years prior. Indeed, in a series of claims comparing the hypothetical wartime scenarios that could confront sea-launched missiles versus their land-based counterparts, NOBSKA proclaimed that sea-based platforms offered definite political as well as military advantages, writing:

> If we are to maintain our deterrent strength, we must be prepared with alternatives to compensate for the loss of overseas bases. If we retire to a Fortress America this tends to increase the general value of the United States as a thermonuclear target. Alternatively we can actively seek to expand and exploit the role of sea-based deterrents: surface and submarine missile

[149] Ibid., 9.

> launchers, long-range seaplanes and carrier striking forces...Furthermore, weapons launched from the sea are less likely to bring retaliatory blows upon our friends and allies.[150]

Here NOBSKA members were taking direct aim at the contemporary Air Force policy of stationing its own strategic forces all over the territories of the United States and allied countries. Measured against the arguments that Navy officers had deployed, unsuccessfully, against the B-36 in 1949, the NOBSKA critique of Air Force plans was in some respects more subtle, even as its conclusions appeared potentially more far-reaching. Referring to the newfound technological opportunities purportedly then open to the Navy, the NOBSKA report stopped short of criticizing Air Force weapons directly, instead pointing to the political challenges posed by allies and adversaries alike as the primary reason necessitating the development of novel sea-based weapons systems. Two assumptions animated this particular judgment: 1) American allies were likely to declare their neutrality early in a conflict between the U.S. and the Soviet Union and 2) the Soviet Union based its nuclear targeting primarily on the location of U.S. strategic forces. To contemporary Navy planners, neither assumption would have provoked much skepticism.[151] Still, the supposition that a missile launched from the sea would be less prone to invite retaliation must have produced some controversy among NOBSKA participants, as a later passage in the report returned to this point for the sake of providing clarification, along with certain qualifications. Not without adding its own inconsistencies, the passage attempted to draw a fine distinction between the strategic consequences that would be

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[150] Committee on Undersea Warfare, National Academy of Sciences, Project Nobska: The Implications of Advanced Design on Undersea Warfare, Final Report, Volume II: Assumptions, Conclusions, and Recommendations, 5.
[151] "Guided Missile Sites in the Middle East," Deputy Chief of Naval Operations for Plans and Policy Admiral Ruthven Libby to Chief of Naval Operations, 25 January 1957, Top Secret, Washington Navy Yard, U.S. Navy Operational Archives, CNO Double Zero Files 1957, Box 12, Folder: X-Ordnance, Design Construction,etc.

likely to arise from the use of nuclear weapons in an ASW role as opposed to against "land targets," writing:

> It has been argued that any use of nuclear weapons would precipitate unlimited nuclear retaliation and indeed it may. However, the use of nuclear weapons against enemy submarines seems less subject to such objection, since clearly the action is against enemy military units at sea and should not involve civilians. Directed against land targets, involvement of civilian populations appears unavoidable. The choice between nuclear and conventional weapons for antisubmarine warfare should be made entirely on the basis of which use will be most advantageous from a political and military point of view.[152]

Interestingly, the distinction here between land targets and submarines – which hewed closely to the prevailing Navy line that its primary target in wartime would be enemy forces at sea – operates equally to obscure the contemporary fact that the Navy had since soon after the end of World War II been formally prevented from taking a more active part in planning wartime operations against certain categories of land-based targets in the Soviet Union.[153] Indeed, one of the most lasting legacies of the previous decade's Air Force-Navy confrontation over roles and missions, the Key West Agreement, amounted to a formal inter-service armistice that attempted to end once and for all the simmering conflict over whose forces would be responsible for carrying out the next war's strategic bombing campaigns. The terms of that agreement forbade the Navy from targeting the urban-industrial centers to which the Air Force had asserted a priority stake, and invented the phrase "targets of naval interest" to specify the alternative target types that would remain available to the Navy and thus considered legitimate guideposts for naval force structure and future procurements.

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[152] Project NOBSKA Final Report, Vol II, 12.

[153] Under the terms of the Key West agreement, concluded among the services in March 1948, the Air Force was assigned principal jurisdiction over strategic air warfare. See Barlow, *Revolt of the Admirals*, 123.

The clear intention of this arrangement was thus to limit the Navy to so-called tactical applications of its existing and prospective forces, by which the Air Force meant to confine the use of naval weapons to their enemy counterparts, and on land targets no further inland than the submarine pens and shipyards dotting the Soviet coastline. Nevertheless, the definition of what exactly constituted a target of naval interest remained vague enough to permit some extreme creative license on the part of naval analysts, such that, for example, a factory located in Gorky that manufactured submarine batteries was classified under that heading.[154] Despite its already lax interpretation of these operating constraints, in the months since being granted the right to participate in a major development program for a long-range ballistic missile, the Navy had begun to revisit its policy of even nominally adhering to the terms of the Key West Agreement. From the beginning, to the operational ranks of the Navy the Jupiter, and even the Jupiter S, strained credulity as a serviceable weapon system, both in terms of its farcically poor fit for existing sea-based platforms and in the seeming impossibility of finding a suitable target.[155] As the Jupiter's range requirement would have placed it well beyond the capabilities of contemporary fleet-based missiles, the program frequently provoked discussions of future forces that steadily stretched the bounds of "naval interest" in the targeting domain. This reality visibly made its way into the NOBSKA report in a number of key respects, the first of which related to the study's treatment of what in 1956 qualified as a target of naval interest. On this point, the report concluded:

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[154] For reference, the city of Gorky (as of 1990, Nizhny Novgorod) is located approximately 1600 kilometers inland from the Baltic Sea, the nearest conceivable patrol area for U.S. submarines. John Coyle Interview, "War and Peace in the Nuclear Age; A Bigger Bang for the Buck, 1986," 26 March 1986, WGBH Media Library & Archives.
[155] Ibid.

> Target analyses indicate that missile yields considerably less than one megaton are adequate for most targets of naval interest and that missile ranges of interest fall into two general categories, less than 500 miles for coastal targets and targets in the Soviet Satellite countries, and up to 1500 miles for targets in the Soviet Union.[156]

Whereas in previous years the phrase "targets of naval interest" had been coined to imply tactical objectives that called for the employment of relatively short-range weapons, its usage here served to resuscitate a long-held aspiration on the part of the Navy to design weapons capable of reaching targets deep in Soviet territory. As we will continue to see, however, even ranges on the order of 1500 nautical miles (and greater) could be characterized as being fully compliant with the previous era's strict interpretation of what fell under the Navy's purview. Indeed, the specter of Soviet ASW became by the mid-1950s a leading rationale for building longer-range sea-based ballistic missiles, as Navy officers argued that U.S. submarines, for the sake of survivability, needed to maintain on their patrols ever greater standoff distances from the territorial waters of the Soviet Union, and were thus still committed to targeting nothing further inland than coastal installations. The inconsistency with which this argument actually informed considerations of naval force planning and weapons design will be more fully explored in the following section.

Beyond the matter of range, the NOBSKA report also claimed that the Navy could just as effectively achieve what it considered acceptable levels of target damage with yields substantially smaller than those that were actively being pursued at the time. Moreover, NOBSKA participants familiar with prevailing trends in warhead miniaturization advised that the weight savings promised by

[156] Committee on Undersea Warfare, National Academy of Sciences, Project Nobska: The Implications of Advanced Design on Undersea Warfare, Final Report, Volume 1: Assumptions, Conclusions, and Recommendations, 35.

reduced yields would soon be augmented with those achievable through advancements in the efficiency of future warhead designs. In a comment that would eventually be immortalized as a founding dictum in the field of military operations research, Edward Teller of the Lawrence Livermore National Laboratory – after listening to several presentations by Navy personnel describing their efforts in the Jupiter development – chided Navy officers for presuming to design a missile, that in many ways strained the state of the art, around a warhead that would soon be rendered obsolete, asking: "Why use a 1958 warhead on a 1965 weapon?"[157] Teller had already stirred up considerable controversy at the NOBSKA meeting by suggesting that megaton warheads would soon be available in the size and weight specifications necessary for use on torpedoes, the Navy's longtime tactical weapon of choice. Unsurprisingly, it was the implications of Teller's prediction for the Navy's ballistic missile work that exerted the most powerful pull on subsequent events.

Word of Teller's claim quickly made it back to Admiral Burke and SPO Director Raborn, who in turn wasted no time in seeking out an independent confirmation of this projection from the Atomic Energy Commission, which they received within a week. Similarly, at the NOBSKA gathering itself, the debate generated by Teller's remark soon produced something of a consensus. Boldly stated in the final report, the recommendation nevertheless sparked unease among some naval officers in attendance who regarded it as a rather brazen departure from the terms of reference they had been given at the outset of the summer study. The offending proposal stated:

> The Navy should vigorously pursue the development of a nuclear submarine – ballistic missile strategic attack system that is consistent with the rapidly advancing state-of-the-art in nuclear

[157] William F. Whitmore, "Military Operations Research-A Personal Retrospect," *Operations Research* 9, no. 2 (1961): 263.

> warheads, rocket propellants, and nuclear propulsion. In order to maximize the flexibility, sustained fire capability and useful life of such an attack system, this development program should be predicated on a reasonable missile weight fixed now, accepting the performance limitation this weight implies. This will permit an immediate start on a submarine design that will be neither prohibitively expensive nor obsolete before its commissioning. Thus the submarine attack system will be available in a minimum time and can still take full advantage of expected rapid improvements in the ballistic missile art.
>
> ...In view of the rapidly improving technology in the nuclear-warhead and ballistic missile fields the Navy should carefully consider the possibility of re-orienting its Jupiter programs toward the design goals outlined.[158]

By "re-orienting," NOBSKA participants effectively meant that the Navy should abandon its partnership with the Army in pursuit of the Jupiter IRBM, in favor of developing a strategic nuclear delivery system capable of being launched from a submarine. In the eyes of several Navy observers, many of whom already nursed a number of misgivings about the merits of pursuing a long-range ship-based ballistic missile capability, such a proposal was a bridge too far. To others, this proposal was distasteful for the simple fact that it effectively promoted the very platform to which Project NOBSKA had been charged with developing countermeasures.[159] Nevertheless, NOBSKA's assessment came as a welcome boon to SPO personnel eager to drop the Jupiter design and start from scratch designing the optimal sea-based weapon. After commissioning SPO's contractors to submit independent evaluations of the NOBSKA proposal, Admiral Raborn, along with the program's new Technical Director Captain Levering Smith, by September had managed to secure the backing of the CNO and the Secretary of the Navy for redirecting the FBM program toward developing a system

[158] Committee on Undersea Warfare, National Academy of Sciences, Project Nobska: The Implications of Advanced Design on Undersea Warfare, Final Report, Volume 1: Assumptions, Conclusions, and Recommendations, 36.
[159] Sapolsky, *Polaris System Development*, 31.

along these revised dimensions. By the end of November, the Secretary of Defense had officially released the Navy from its commitment to the Jupiter missile and the following month authorized the initiation of an independent Navy program for the development of an intermediate-range submarine-launched ballistic missile, dubbed Polaris.

If it seemed counterintuitive that a major new weapons system designed for use aboard submarines would owe its origins in large part to the deliberations of a symposium on anti-submarine warfare, the following section will demonstrate the extent to which the FBM program and contemporary ASW R&D evolved a symbiotic relationship in the latter half of the 1950s. The functional marriage between these domains, carried out by means of mutually reinforcing financial and operational investments, became a necessary condition on which both initiatives would depend for their continuation. Their proponents increasingly believed that each, without the other, would become vulnerable to any number of attacks from various quarters in the midst of an ever more competitive budgetary ecosystem in which defense officials sought to corral what they considered an effectively anarchic military R&D establishment.

Selling (in)vulnerability: Polaris as "the Marilyn Monroe of the ballistic missiles"

Securing an official mandate from the Pentagon for the development of the Polaris SLBM marked only the beginning of SPO's long campaign to legitimize the program in the eyes of many in its home service. As it had been approved in the interim between budget cycles, the new FBM program would need to finance itself out of the existing Navy appropriation before lawmakers could introduce

its own dedicated funding in the FY 1958 defense authorization. The startup costs to the Navy had been steep, amounting to approximately 15,000 personnel being dropped from the organization's payroll.[160] Describing the air among contemporary admirals regarding the Polaris concept, Admiral Raborn testified that:

> Most of them felt that it would be a waste of money, a tremendous drain on the Navy's budget, and that it would not be successful...the Navy would get a big black eye out of this program...They had charge of building submarines and destroyers and aircraft and aircraft carriers, and so on.[161]

Thus, the price of being granted special favor by the civilian defense establishment was having to contend with a deficit in political capital within the officer class of the Navy. As SPO's lead public relations manager, Clement Hayes Watson, later recounted: "at that time the Polaris program had about two friends. One of them was the Chief of Naval Operations and the other was the Secretary of the Navy." As a first order of priority, Admiral Raborn assigned Watson the task of developing a series of custom sales pitches to improve the image of the Polaris program within the Navy. He characterized the main discursive ingredient that went into his presentations in the following terms:

> [W]e had to develop the fact that the Russians were building these things – that the Russians had a missile program – so we had to have a defensive operation...every time the Russians sent somebody into outer space winging around the earth, why, it gave [the Polaris program] another push because it showed that these things could be done, and I think that helped us a lot.[162]

What Hayes meant by having to "develop the fact" of a Russian missile program can be seen in his instrumental approach to the claim "that the Russians were building these things" — that is, the

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[160] Admiral Arleigh Burke Interview.

[161] Vice Admiral William F. Raborn Interview.

[162] Clement Hayes Watson, Interview with John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 17 November 1972.

point of developing this fact was in legitimizing the Polaris program as "a defensive operation." The presumed scale and urgency of the Soviet missile threat indeed figured prominently in SPO's outward-facing pronouncement regarding the Polaris program. In the context of SPO's internal deliberations, however, it was a very different dimension of possible Soviet action that animated debates over how to assess the FBM's operational effectiveness once it reached deployment. At one of the earliest meetings of SPO's Special Task Group in January 1957, the head of the program's Operational Requirement Interpretation Subcommittee (ORIS), Dr. William F. Whitmore, proposed that the group adopt a measure of effectiveness for the Polaris system premised on "inferred Soviet allocation to countermeasures against POLARIS."[163] He went on to draw out several implications of proceeding with such a definition:

> Several implications should be noted. First, the mission is deterrent, as specified by a CNO letter read to the meeting. Second, POLARIS contributes to the overall U.S. deterrent capability; it does not assume the whole load. Third, POLARIS is a deterrent only if the enemy senses a threat; the importance the enemy places on that threat is measured by his attempt to eliminate it (unless he surrenders to it -- which seems improbable). Fourth, decoys may dilute the enemy's counter effort, but some submarines must be able to make good on the threat -- and this fact must be known in general terms to the enemy. Fifth, Soviet effort is inferred from intelligence sources and from estimates of enemy intentions. The contribution by the NOBSKA Study Report to this line of thinking is evident.

In effect, Whitmore's definition of effectiveness hinged on the magnitude of the Soviet Union's ASW response to the deployment of the Polaris weapon. Following the definition to its logical conclusion ultimately leads to the same overdetermined outcome as previous metrics for assessing the survivability of various types of naval forces. That is, whether or not the FBM performed

[163] "Proceedings of the Steering Committee of the Polaris-Submarine Special Task Group," Second Meeting, 24-25 January 1957," 1957,3.

according to expectations, the result would inevitably prepare the grounds for a follow-on development by creating a requirement for a more effective FBM. If the system proved effective, Soviet ASW would by definition erode its deterrent value over time; and conversely, if the system proved ineffective (by failing to attract Soviet countermeasures), it followed that a more effective deterrent system would need to be built. As it stood, the interim capability that the CNO had set for the first-generation Polaris was defined to be "directed against a complex of one or more soft targets of about four miles diameter each requiring a missile range band of 500 to 1200 nautical miles" while the so-called "ultimate capability" was set to "be effective against a target complex requiring a missile range band of 300 to 1500 nautical miles."[164] As an addendum to the initial OR, the CNO further cautioned the SPO team that their initial design "should consider a possible future requirement to be effective in tactical employments."

While the stated requirement thus clearly identified "soft targets" (read cities) as the targets of naval interest in the case of the first FBM, with only the long-term possibility floated of a tactical use scenario, the contemporary statements of SPO personnel in various quarters around the national military establishment indicated the exact opposite. As Gordon O. Pehrson, SPO's Director of Plans and Programs, attested:

> The Navy was parading this weapon system as something they were going to use to knock out the submarine pens, even though we knew right from the beginning that it was a strategic weapon.[165]

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[164] "Proceedings of the Steering Committee of the Polaris-Submarine Special Task Group," Second Meeting, 24-25 January 1957, Appendix B.

[165] Gordon O. Pehrson, Interview with John T. Mason, Series of Interviews on the Subject of Polaris, U.S. Naval Institute, 5 February 1974, 39.

Pehrson further took pains to clarify that the risk of calling the Polaris a strategic weapon emanated from the Air Force position that it should control all U.S. forces that fell under that heading. Thus, the claim that the Navy missile would serve in a tactical role constituted a tactical maneuver of its own, as, in Pehrson's words, "the Navy wasn't about to let the Air Force start running the fleet."[166] To be sure, in the earliest phases of the Polaris program, SPO had intentionally left open to interpretation many of the specifications of the missile they were engaged in building. Commander Freitag of the missile subcommittee of the STG demonstrated this point clearly enough when he answered a query from the group's Technical Director about the importance of obtaining a 300 nautical mile minimum range in the initial Polaris weapon:

> [W]hen the OR was written, it was not generated around specific launching areas and targets as are now being considered as the initial employment plan. If this is going to be a difficult requirement to meet, SP[O] should officially request that this requirement be changed.[167]

In other words, SPO personnel regarded the setting of operational requirements more as a practical expedient than as a fixed goal. To be sure, this tactic of proactively managing expectations around the program proved instrumental in later historical accounts of the Polaris development which pronounced it such a resounding success.[168] Nevertheless, in the spring and summer of 1957 success remained far from assured, and SPO's development philosophy reflected a corresponding degree of risk-aversion by committing the program *not* to strain the contemporary state of the art in any field

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[166] Ibid., 40.

[167] "Proceedings of the Special Projects Office Steering Task Group--Task II--First Meeting," Monitor and Sponsor FBM Development Program, 25-26 July 1957, 51.

[168] For an account that critically examines the "social construction of success" in the case of the Polaris program, see Graham Spinardi, *From Polaris to Trident: The Development of US Fleet Ballistic Missile Technology* (Cambridge University Press, 1994).

relevant to the construction of an "interim" FBM system. With the operational requirements free to vary according to the demands of the program's development timeline, the question of what exactly the deployed Polaris weapon was supposed to hit for a time had in fact no stable answer.

In early 1957, and through the end of the decade, SPO officials faced a thorny public relations conundrum. Arguments against Polaris at the time could draw on any number of compelling premises: the system was "unproved," it encroached on the strategic targeting mission that was the exclusive responsibility of the U.S. Air Force, and early on its unknown production costs made it relatively straightforward to cast as an ineffective use of funds better spent on better-known quantities such as land-based ballistic missile squadrons.[169] That by and large it was representatives of the U.S. Air Force circulating these arguments did not mean that they lacked a sympathetic hearing in many corners of the uniformed Navy.

Indeed, particularly throughout the first half of 1957, the fronts were so numerous that SPO personnel, according to Pehrson, "had to convince an awful lot of people that what we were saying was true because there were an awful lot of lies being talked around Washington, some of them based on ignorance, some on malice."[170] By July of that year, however, Admiral Raborn felt confident enough to declare to the assembled STG members, representing offices from across the Navy and affiliated industry and university contractors, that the FBM program was officially "here to stay." After months of politicking among the Navy brass, Congress, and the White House, Raborn shared with the group at that July meeting his sense that their enthusiasm for the program "has caught on,"

[169] CNO Personal No. 36, To: Flag Officers, Subj: Dope, 2 April 1958, .

[170] Gordon O. Pehrson Interview.

and that legislators in particular were beginning to be swayed by the idea that Polaris "was the Marilyn Monroe of the ballistic missiles."[171]

Raborn went on to highlight a May 27 speech by Senator Henry M. "Scoop" Jackson (D) of Washington, then a sitting member of the Senate Armed Services Committee, as evidence that the SPO rationale for the FBM was beginning to stick.[172] By mid-1957 Polaris proponents had indeed hit their stride with respect to the task of garnering a stable base of external support, yet their standing within the Navy hierarchy remained relatively insecure. Just a couple of weeks after the STG's July meeting, however, there came an assist from a familiar quarter. During a four day long conference at the Naval War College in early August 1957, a subset of the original Project NOBSKA participants gathered to review both the extent to which the previous summer's recommendations had been implemented and the extent to which they required clarification or update. This review, undertaken at the behest of ONR, carried on the tradition of summer studies past which presented R&D as the panacea par excellence for perceived deficiencies in contemporary naval force structure. Moreover, NOBSKA alumni did not shy away from pushing the Navy on a number of points, declaring early in the report that:

> The Navy must find a way of providing the men, ships, and submarines, not only for the gathering of basic data, but for the testing and experimental evaluation of new devices and

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[171] Raborn in all likelihood meant the comparison to sound as arresting as it did. Years later, in his interview with John T. Mason, Pehrson placed the sentiment in the context of contemporary public narratives surrounding the Polaris system, characterizing it as "a real sexy program because it was invulnerable, it stalked unknown — you could put all the PR words around it and yet you were telling the truth. A submarine can lie under the ice caps like a rattlesnake under a stone and so on! I mean we could get some good people who knew how to carpenter the right kind of words." Pehrson Interview, 36-37; "Proceedings of the Special Projects Office Steering Task Group--Task II--First Meeting," Monitor and Sponsor FBM Development Program, 25-26 July 1957, 1.

[172] Senator Jackson's remarks characterized Polaris as a "real deterrent" which "does not serve as a magnet to draw to these shores the fury of the enemy's initial attack." Ibid., 2.

> techniques in the research and early development stages, while flexibility in design and method of employment is still available.[173]

Thus characterizing R&D as both a malleable and fungible military resource, the review's authors set out to demonstrate this principle through a series of arguments for why the Navy needed to maintain high-priority investments in improving the navigational accuracy and stealth of existing nuclear-powered submarines. In the course of lamenting the "economic climate" that had driven the year's rash of cuts to experimental research, they lingered especially on a critique of the Navy's decision to fund a U.S. Coast and Geodetic Survey of the West Coast at the expense of conducting topographic surveys of the seafloor throughout designated SLBM launch sites as recommended by the Project NOBSKA study. Despite the fact that even the most fervent supporters of the Polaris program did not foresee that system approaching the accuracy levels which would justify incorporating the relatively miniscule error corrections that would result from such a large-scale effort, the review maintained it would be necessary if considerations "of safety and general navigation of deep-running, high-speed submarines are expected to be important in the period 1965-1970."[174] In other words, they argued that if the Navy wanted to retain the option of future generations of the FBM ever obtaining accuracies much better than a 2-nautical-mile average miss distance, undertaking a high-resolution topographic survey of the ocean floor would become obligatory in the immediate future.

This caution dovetailed with the NOBSKA members' alarmed assessment that "reports of probable withdrawals of already inadequate supporting submarine platforms and target services from

[173] Committee on Undersea Warfare, National Academy of Sciences, "Review of Project NOBSKA," August 5-9, 1957, 5.
[174] Ibid., 12.

sonar laboratories," if true, risked "crippl[ing] the laboratories irreparably and would, in our opinion, seriously jeopardize the Navy's readiness to meet the undersea warfare threat a decade hence almost irrespective of the funds which might be available then."[175] It is important to note that – to scientists in the world of naval R&D – quiet, deep-diving submarines were not only weapons systems, but also research platforms necessary for the collection of certain kinds of data of special interest to those, for example, who served on the NRC's Committee on Undersea Warfare and in ONR-funded laboratories.[176]

In an analogous fashion, calls to lay the groundwork for future increases in navigational accuracy were matched by similar pleas to pursue the development of less noisy naval reactors. On this score, NOBSKA members remained highly skeptical of the idea that contemporary pressurized water reactors represented anything approaching an optimal propulsion system, going so far as to say that the move to nuclear power in ships and submarines "in moving us ten steps forward with respect to the quality of endurance, unfortunately has moved us backward one or two steps with respect to quietness of operation and ship size."[177] Commenting on the Navy's decision to monitor contemporary Air Force efforts to build small naval-reactors for aircraft rather than undertake its own dedicated line of research in this area, the NOBSKA review advised that:

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[175] Ibid., 9.

[176] For further reading on the material and epistemological constraints that Navy sponsorship placed on civilian oceanographers, see Naomi Oreskes, *Science on a Mission: How Military Funding Shaped What We Do and Don't Know about the Ocean,* (Chicago: University of Chicago Press, 2021).

[177] Committee on Undersea Warfare, National Academy of Sciences, "Review of Project NOBSKA," August 5-9, 1957, 20.

> [I]t is insufficient for the Navy merely to monitor the ANP [aircraft nuclear propulsion][178] program, the success or failure of which is not necessarily relevant to naval application. We would therefore encourage a vigorous search for feasible new reactor propulsion systems which promise major improvements in size and space over present systems…The submarine-launched ballistic missile weapons system alone would profit so much that the present high-priority development program could well supply some of the fiscal support as well as justification.[179]

Here NOBSKA alumni were referencing a recent development in which the Pentagon had granted the Polaris program the highest priority funding status that had previously had been reserved exclusively for Air Force programs. In the scientists' view, now that the Navy had an urgent national priority program of its own, they argued that it could support a broad range of initiatives of long-term relevance both to the FBM and the Navy at large. Indeed, there were few, if any, R&D corners NOBSKA members felt could be cut with respect to the task of mitigating the disadvantages they saw in existing pressurized water reactor designs.[180] To that end, they recommended not only immediate efforts to reduce reactor size, but "a major re-engineering of every item in a ship – from the power plant on down – where weight and space savings are seen possible," and went on to justify such an initiative on the grounds that "the potential rewards are great and the survival of the combatant surface ship may very well be at stake." Reducing the overall size of future ships was also taken to be an important goal for reasons relating to increasing the flexibility of the overall fleet, which NOBSKA

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[178] For an overview of Air Force efforts to develop nuclear-propelled rockets, see Vince Houghton, *Nuking the Moon: And Other Intelligence Schemes and Military Plots Left on the Drawing Board*, (New York: Penguin Books, 2019).

[179] Committee on Undersea Warfare, National Academy of Sciences, "Review of Project NOBSKA," August 5-9, 1957, 17.

[180] From an ASW perspective, propulsion reactor designs were key determinants of the overall noise profile of a submarine on patrol. A larger reactor could power a faster submarine, but it also made for a noisier, less stealthy one. Minimizing reactor size thus became a prominent goal of ASW-conscious submarine designers. This tradeoff between speed and stealth would become a major point of conflict within the Navy during the 1970s, pitting Rickover and his reactor branch against much of the rest of the Navy's scientific and technical personnel.

members argued depended on adhering to the principle that "larger numbers of small submarines are better than smaller numbers of large submarines." In conclusion, the report justified the scale of its renewed recommendations on the basis that:

> [F]or a research and development program to be effective and economical a considerable percentage of the effort should be directed towards solving problems that will probably not arise for 10 to 15 years. We must not be so preoccupied with the present that we neglect the future.[181]

To come now more directly to the matter of what underpinned the NOBSKA review's claims and proposals, certain hardwired assumptions about ASW that had been at work for the better part of a decade were, throughout the mid-1950s, butting up against prevailing economic realities reminiscent of the funding situation that had faced scientists in the years between 1945 and 1950. Indeed, ONR support of university-based research had by 1957 plummeted nearly to its pre-Korean War levels, a trend scientists feared would only continue absent a more concerted effort to justify R&D on the basis of existing military requirements.[182] Prior to the funding bonanza touched off by the launch of Sputnik later that year, ONR scientists and their colleagues in academia and industry drew principally on their experience of those past moments when research dollars had become scarce commodities, developing rationales for R&D initiatives rooted as deeply as possible in the pressing operational concerns of Navy personnel. To take one particularly striking example of this principle at work, consider the following recommendation for a future ASW surface vessel, put forward in the context of steep cuts to the Navy's shipbuilding budget and renewed concerns within the Bureau of Ships that

[181] Ibid., 26.

[182] Sapolsky, *Science and the Navy*, 132.

the fleet's surface components would soon become a casualty of the service's increasing emphasis on submarines:

> We are not sure what kind of surface ship will be an effective ASW element ten years hence, but we know of absolutely no way of exploring the features that such a ship will require other than through the construction of a pre-prototype ship.[183]

To be sure, it is not clear whether the arguments of NOBSKA alumni would have succeeded were it not for the tide of defense spending that lifted all boats in the years following the flight of Sputnik. Nevertheless, when that tide did arrive, it found no shortage of grooves already dug to direct it along particular R&D channels, many of which had been carved out with the help of years of ASW-inflected rationales. Thus, even as they held up "the true submarine" as ushering in a revolutionary new era in the domain of undersea warfare, scientists in the world of Navy-sponsored R&D remained as financially and ideologically invested as ever in pointing out that the pendulum would soon inevitably swing back from measure to countermeasure.

Finally, to turn back to contemporary developments within SPO, the remainder of this section will trace the ways in which Polaris program officials responded to the design pressures they believed to be operative in the context of contemporary concerns regarding the ASW threat. Six weeks after NOBSKA alumni had gathered at the Naval War College to review the year's developments, SPO officials met to discuss the results of a study on possible Polaris countermeasures conducted by Lockheed, the Polaris system contractor. The Lockheed representative sent to present the study's findings to the STG summarized the primary countermeasure risk in the following terms:

[183] "Review of Project NOBSKA," August 5-9, 1957, 20.

> The enemy reaction is assumed to be concentration of search effort when all-out war is to be initiated (by him); infra-red detection of the initial missile firing, followed by radar ranging on the ionized exhaust of succeeding missiles; followed by direct attack on the submarine from jet aircraft. About thirty aircraft on station per million square miles of search area result in the expected value of fifteen minutes dead-time in the aircraft attack. Under these conditions, it is evident that the entire missile load will not, on the average, be fired before attack. A decrease in firing rate to one every two minutes would indicate the desirability of smaller submarines, each carrying fewer missiles. An extension of the attrition analysis to the pre-launch phase concludes that effective action against the submarine in transit or on station is quite improbable, and that simple tactical measures (cover, evasion, decoys) can seriously degrade enemy efforts. (Safety of the submarine in the pre-launch phase is enhanced by rather poor Soviet ASW capabilities, as assessed by ONI [Office of Naval Intelligence]). Essentially, the submarine is invisible before firing and blindingly obvious after it.[184]

In the group's subsequent discussion of the results, Captain Smith posed the question of whether members "saw a difference between the capabilities of: (1) being able to fire the missiles within 15 minutes and, (2) being able to fire them over a period of say, two days." Commander Paul H. Backus, who attended as a representative of the CNO, responded first, saying that an immediate strike capability would be necessary "for the double purpose of psychological as well as physical destruction." Others, however, were more circumspect, as one official reasoned that:

> It is the sureness of the FBM retaliation which makes it such a powerful deterrent…Perhaps even after the first blows have been struck and SAC has done all it can, the Navy might still have these submarines ready. The Russians will know that even though they may win the air battle, they won't win the war.[185]

In the end, the range of opinions voiced on how and even whether to respond in design terms to the firing rate problem identified in the Lockheed study resulted in a two-pronged working compromise. While the group eventually endorsed a submerged firing rate requirement of 1 missile

[184] "Task II--Monitor and Sponsor the FBM Development Program," Second Meeting, 26-27 September 1957, 3.
[185] Ibid., 7.

launch per minute, in the ultimate employment concept the launching capabilities of the Polaris system were always described as capable of ensuring "inevitable retaliation, either immediately, or with deliberate response."[186] This solution fit neatly into the design philosophy of SPO, which held that the operational flexibility of the deployed system should remain the overriding consideration driving all other tradeoffs. Indeed, previous studies of Polaris have provided extensive documentation on the range of design compromises struck by SPO personnel for the sake of staying on track with the program's punishing development timeline.[187] What I am arguing here is that, while considerations of cost and scheduling were indeed paramount, not everything was as subject to compromise for the sake of producing a cheaper, more readily available system.

While the goal of flexibility seemed to contain in many ways its own array of cost-saving and time-saving tradeoffs, the pursuit of this property more often than not presented a greater challenge than would have existed if the Polaris team had a more defined operational mission around which to design that system. For example, at the same September meeting during which SPO personnel first discussed the firing rate problem, members of the re-entry body subcommittee voiced frustration that they had been given the task of "designing a fuze capable of being used against all types of targets, hard and soft."[188] Arguing that they could more rapidly arrive at a far less complicated design if only they could receive a "better definition of the type of target to be engaged by the FBM," their request for greater specification was nevertheless dismissed without comment. Notably, despite the system's

[186] "Concept of Employment and Command Structure for the Polaris Weapon System," 22 January 1959, 1571.
[187] Spinardi, *From Polaris to Trident*.
[188] "Task II--Monitor and Sponsor the FBM Development Program," Second Meeting, 26-27 September 1957, 21

operational requirement and subsequent employment concepts promulgated by the office of the CNO that clearly designated the Polaris A1, as the first-generation FBM came to be called, for use against "soft targets," the requirements issued for the fuzing component on the re-entry body demanded flexibility in the types of targets against which it could be programmed.

Within a year of Sputnik placing all existing U.S. ballistic missile developments on a crash schedule, the first round of Polaris AX test flights had gotten off to a rocky yet by most accounts reasonable start by late September of 1958. The more difficult series of tests, however, had already begun. That January, the Navy had submitted to the Secretary of Defense a formal request to accelerate the deployment schedule of the Polaris program for a second time, to increase the number of authorized FBM submarines from three to nine, and to augment the service's ASW budget, for a total of roughly $2.6 billion in supplemental funds over the regular appropriations for FY 1958 and FY 1959. As both the Army and the Air Force had also submitted supplemental funding requests for their priority programs, the following month Secretary McElroy invited each of the services to comment on the total supplemental request that DOD would submit to Congress through the President. Unsurprisingly, neither the Army nor the Air Force had encouraging feedback regarding the Navy's $1.2 billion request for the Polaris program, nor its $957 million request for ASW ships, aircraft, and R&D. In an internal memo summarizing the other services' commentary, Admiral Burke circulated the following Army and Air Force views to his senior staff:

> On POLARIS the Army stated that the feasibility of the system is still unproved, the missile is too inaccurate for effective use against priority targets, and therefore the system will be effective only against urban and industrial targets rather than specific targets such as submarine pens, air fields, and missile sites. This places POLARIS in the category of an over-all deterrent system and

> raises the question of how much and what proportions of ICBM's, IRBM's and atomic-capable aircraft are required.
>
> The Air Force stated that POLARIS is open to question on: (1) The ability of the system to maintain an alert on station and its ability to fulfill specific target commitments. (2) Its accuracy except when located at or very near, previously surveyed geographical or oceanographic points. (3) Its ability to transmit and receive communications while submerged, and thus its ability to respond to centralized control.
>
> On ASW the Army stated that funds already budgeted are sufficient for construction of ASW ships and aircraft...The Air Force, commenting on ASW, stated that the Navy must face the decision to channel funds into higher priority projects and reduce forces such as the attack carriers, whose principal capability is associated with local war.[189]

In the end, the Navy received $634 million in supplemental funds, roughly one third of its original request, $400 million for Polaris and $125 million for ASW. What peeved Admiral Burke beyond the Navy's less than stellar showing among the Joint Chiefs was an Air Force request for $259 million in funds to develop the solid-fueled, shore-based mobile Minuteman ICBM, for which it had just issued system requirements in August 1958. The CNO was blunt in his interpretation of this item when he wrote: "It appears that by means of the MINUTEMAN project the Air Force hopes to kill our POLARIS program."[190] In fact, Admiral Burke was not far off in that assessment, and it was not until 1960 that the Air Force eventually switched tacks and attempted, also unsuccessfully, to wrest control of the soon-to-be-operational fleet of Polaris SLBMs for itself.

The twilight years of the Eisenhower administration were fraught with political challenges to both the existence and autonomy of the Polaris program, challenges to which SPO personnel felt

[189] CNO Personal No. 36, To: Flag Officers, Subj: Dope, 2 April 1958, 12-13.

[190] Ibid., 14.

themselves obligated to respond proactively. By September 1959, the Polaris team was juggling three separate development programs in various stages of design and flight testing. The youngest of the initiatives, what would become the Polaris A3, had yet to be defined in a number of key subsystems, including with respect to the nature of the re-entry vehicle (RV). On September 3, the STG discussed what they perceived to be the pros and cons of pursuing either of the RV designs then under consideration – a several hundred kiloton single-warhead RV, or a lower-yield cluster-type warhead. The strongest advocates of each of the competing design proposals were, respectively, OCNO staffer Commander Paul Backus and Lockheed senior SPO representative Willis Hawkins.

According to Backus, the single high yield warhead had demonstrated advantages in effectiveness (i.e. target damage) relative to the cluster design that would accrue with time, "in that targets may become much harder as time passes." Moreover, he pointed out that the single-warhead design had performed better than the cluster in studies against point targets, against which he argued "the cluster would not hold up at all."[191] For Hawkins, the advantages of moving to a cluster-type RV were several. He summarized that:

> In most cases, using the cluster, you would get a great deal of 'beneficial destruction' even though you did not land right on the hard point, – as much as from a megaton single warhead. Essentially what has happened here is that we now can obtain this kind of destructive yield by using the cluster. We pay no penalty in range, nor do we use untested components. If we tried to gain this capability with a single tested megaton warhead, we would pay a heavy range penalty. I think we must concentrate on capability, and I cannot help thinking that the cluster offers more than the present 0.5 megaton single. We have the single 0.5 megaton warhead and we can go back to it at any time.[192]

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[191] "Proceedings of the Special Projects Office Steering Task Group: TASK II," Monitor and Sponsor the Fleet Ballistic Missile Development Program, Fourteenth Meeting, 3 September 1959, 8.
[192] Ibid., 11.

The sticking point for the high yield warhead, Hawkins maintained, was its size and weight characteristics, which he argued would result in an overall loss in capability compared to a light RV with comparable target effects. Still, even in 1959, three generations into the FBM program, no system-level decision had yet been taken on whether future designs should optimize for use against point targets or area targets, and thus SPO personnel could look to no firm operational objective to adjudicate between the two RV proposals. What ultimately became determinative, however, was nothing related to the operational performance of the weapon at all. After Backus clarified to an understandably puzzled SPO member that the planners in the office of the CNO were not in fact officially seeking to turn Polaris "into a tactical weapon," Hawkins jumped in to offer what he believed to be the most compelling reason to opt for the cluster-type RV at that juncture:

> One point worth considering here is that while I am sure, and possibly some of you are, that the enemy will not be able to mount an efficient defense or Anti-ICBM, there are people who will argue this point politically, and they will prevail. We shall be forced to design for a defense system that many of us do not feel will exist. If we do not pretend that defense is possible, we shall be open to substantial censure. All I am suggesting is that we do it before we are forced to do it.[193]

Hawkins' point was a distilled but perfectly representative instance of how the Navy's technical personnel and their colleagues in industry and academia had learned to navigate the rarified space where only a relative few besides found themselves institutionally or epistemically empowered to challenge their claims about the nature of or need for a given weapons system.

[193] Ibid., 14.

Conclusion

The Polaris A3, when it reached deployment in September 1964, became the first ballistic missile equipped with multiple RVs, a design choice which was justified officially on the basis of the contemporary Soviet anti-ballistic missile (ABM) system and the threat this posed to the survivability of existing U.S. nuclear forces. Surely enough, nearly ten years to the day following that September meeting of the STG, a months-long national debate over missile defense ended in a narrow – soon to be temporary – victory for a Nixon administration that had already committed to fielding an ABM system, one whose rationale had morphed several times before the public eye and by then was nominally designed to protect the country's missile fields. The 1960s, for all that we know of that period's importance for the history of the Cold War "arms race" and the dislocating milestones that defined it, was nevertheless preceded by a decade in which most of those later controversies had gestated.

Over the course of the 1950s, what began as the problem of vulnerability quickly became an object of study and a resource all its own. Within the Navy, the technopolitical affordances that came to be associated with the idea of vulnerability during this time can be seen in the ways vulnerability enabled (and at times compelled) technical personnel to forge common interests even across functionally antagonistic domains of specialization. For example, when the FBM program became a major sponsor of ASW-relevant research despite ubiquitous public claims of the invulnerability of ballistic missile submarines, it was reinforcing a mutualistic arrangement between these two domains of R&D. Another technopolitical affordance can also be seen in the ways program rationales rooted in

vulnerability permitted epistemically empowered communities to advance unverifiable claims about the existential need for particular lines of research and development, as when scientists and Navy officials alike made frequent reference to the growing sophistication of Soviet ASW capabilities. Lastly, these affordances become perhaps most strikingly visible in the ways that projections of future vulnerability gave security and longevity to programs whose rationales rapidly came unglued from their day-to-day work and whose political fortunes would otherwise have easily been threatened by contemporary realities.

The earliest definition of what constituted a "target of naval interest" was forged at a specific historical juncture to serve a definite political, technological, and operational purpose. Nevertheless, individuals within the Navy over time exercised greater and greater agency in their interpretation of that interest, to the point where the semantic drift produced by this tension itself became a useful tool in their search for flexibility. In the case of the FBM, the technical communities most directly responsible for the advent and evolution of that program, as well as the ways in which it has subsequently been historicized, built on a set of practices that the undersea warfare community had put in place hardly half a decade earlier. These practices over time became sanctified principles that would define the proper management of military R&D within the Navy and the distribution of benefits that would attend such arrangements. Taken together, the measure-countermeasure dialectic that emerged from the establishment of a running dialogue between work on submarine design and anti-submarine technologies made it practically impossible for the substantive collaboration between the military, industry, and academe to yield a weapon any less vulnerable than the last.

IV: "Throwing a dart and then drawing a bullseye around it:" Survivability and the multiple meanings of multiple warhead technology, 1959-1972

> "Most of us saw the role of Poseidon as not different from the role of its predecessors, namely providing an absolutely dependable, reliable deterrent, and most of us were sceptical about the need to dig out hard targets as an essential element of deterrence. We went along with it to the degree necessary to keep the program. The nature of democracy…is that you're constantly making compromises with conflicting constituencies, and we had to serve the reigning constituency even if we, sometimes we felt they were a little nutty."[194]
>
> –Rear Admiral Robert Wertheim, 1985

> "It is perhaps difficult to imagine 'first-strike'…as a rational political alternative undertaken by any nation under any circumstances, but it is nevertheless difficult to postulate a less extreme case as a sufficient measure of the invulnerability of a deterrent force–at least one which must be politically convincing domestically."[195]
>
> –Robert Morse, 1972

Introduction

Marvin Stern was a familiar face around the Pentagon. Even after leaving, midway through the fraught election year of 1964, to become president of the Kearfott Division of the General Precision Electric Corporation, he remained a fixture in Washington. So it was by no means unusual when one day that summer he chanced upon his former boss, Director of Defense Research & Engineering

[194] Interview by Donald MacKenzie, 4 March 1985. Quoted in Graham Spinardi, *From Polaris to Trident: the Development of Fleet Ballistic Missile Technology* (Cambridge: Cambridge University Press, 1994), 86.

[195] Kosta Tsipis, Anne H. Cahn, and Bernard Taub Feld, "The Future of the Sea-Based Deterrent" (Cambridge, Mass: MIT Press, 1973), 4.

Harold Brown, just outside the Potomac River entrance of the Pentagon. Brown was on his way to testify before Congress, where he was scheduled to defend, among other things, the administration's recent decision to cancel the Air Force's long-embattled Mobile Medium-Range Ballistic Missile (MMRBM) program.[196] As the newly installed president of Kearfott — the lead guidance contractor for the erstwhile MMRBM — Stern was beginning his tenure scrambling to mitigate the financial fallout to the company following the program's cancellation.

Aiding Stern in this endeavor was the extensive list of contacts he had amassed from his previous roles as Assistant Director for Strategic Systems under Brown and, prior to that, a longtime member of the Air Force's ballistic missile program. Having caught Brown en route to Capitol Hill, Stern took the opportunity to explain just why Kearfott's controversial guidance system was worth salvaging from the defunct MMRBM project, saying "that stellar acquisition feasibility…that's interesting for its own sake, you ought to keep that alive."[197] Losing the Air Force contract not only meant losing the sole existing client for Kearfott's promised product; it further spelled an imminent drought in R&D funding, at a time when stellar guidance advocates had not yet managed to demonstrate the plausibility of using star-sightings to guide future missiles. One of the few firms to have made significant investments in this technology at the time, Kearfott could ill afford the loss of government support so far out from the prospect of developing a viable system. Characterizing the R&D effort as taking up mere pennies on the defense dollar – $40 million over the next fiscal year –

[196] Quoted in Donald MacKenzie, *Inventing Accuracy: a historical sociology of nuclear missile guidance* (Cambridge, MA: MIT Press, 1990), 284.

[197] Interview with Marvin Stern by Graham Spinardi, 13 July 1987. Quoted in Ibid.

Stern convinced Brown to advocate for continued funding to Kearfott's Stellar Acquisition Flight Feasibility (STAFF) program even in the absence of a candidate missile system that could make immediate use of the technology.

Stern's successful appeal kept fortunes afloat for stellar-inertial guidance long enough for another patron to emerge from among the military branches. The Navy's Special Projects Office (SPO) – fresh off the milestone of deploying the third generation of the Polaris SLBM – took a special interest in Kearfott's novel approach to supplementing the accuracy of existing "black-box" guidance systems.[198] SPO's search for accuracy was far from straightforward, however. In mid-1964, SPO personnel were still skeptical of the need for a more accurate successor to the Polaris A3, whose 0.5 nautical mile (nm) average miss-distance comfortably satisfied requirements for city-targeting. In addition, the 2,500 nm range of the A3 placed it well beyond the operating requirements imposed by intelligence projections of Soviet ASW. Nevertheless, having been pressured by the DDR&E and the Office of the Secretary of Defense (OSD) into developing a more accurate follow-on FBM system despite the organization's misgivings, SPO officers rallied around the task of securing as much autonomy for the new program as they could within the constraints already passed down by the Pentagon's civilian leadership.

Among the most onerous of these constraints was the requirement that SPO work directly with the Air Force on the development of the Mk. 12 reentry vehicle, which by late 1964 was the

[198] The primary difference between stellar-inertial guidance and traditional "black-box" guidance systems was the former's incorporation of a star sensor, essentially a small telescope which would relay the observed position of a sighted star during flight back to the missile's guidance computers. This measurement would then be compared to the predicted position of the sighted star and used to correct for errors in the initial position and azimuth of the missile. See MacKenzie, *Inventing Accuracy*, 245-255.

leading candidate RV for both the Minuteman II and the Polaris B3, as the latest FBM generation was then called.[199] Authorized in March 1964 on the condition that it proceed as a joint Air Force-Navy development, the Mk. 12 was from the very beginning a source of frustration for SPO officers and their industry partners. Aside from the felt imposition of having to use a reentry vehicle optimized for both (and thus neither) Air Force and Navy requirements, the drawbacks of the Mk 12 RV for the purposes of SPO's continued independence were multiple and exacerbated by the FBM program's increasingly high profile within the Navy, a trend which brought with it growing conflict between SPO and the service's civilian and military leadership over the strategic justification of future Navy ballistic missile systems.

Central to this dispute were shifting contemporary conceptions of the technical requirements necessary to operationalize a counterforce nuclear strategy. Over the course of the 1960s, the conventional wisdom among military planners regarding what features constituted a counterforce weapon underwent a dramatic, though uneven and oft-contested, transformation. Where before Navy and Air Force planners had long considered the ideal counterforce weapons to be characterized by large throw-weights (effectively, large missile sizes) and high-yield warheads, by the mid-1970s even Air Force thinking had been transformed to the extent that a 1976 internal review of the history of MIRV development equated a counterforce capability with the deployment of large numbers of highly accurate, *low-yield* warheads.[200] When guidance from the office of the CNO first prompted SPO to

[199] What would ultimately become the Poseidon C3 was over the course of its design and development previously known as the Polaris B3 and the Polaris A3a.

[200] Daniel Buchonnet, "MIRV: A Brief History of Minuteman and Multiple Reentry Vehicles," Lawrence Livermore National Laboratory, February 1976, 6.

begin work on a fourth-generation FBM in September 1963, the assumptions of counterforce proponents within the ranks of the Navy's military and civilian leadership still clustered around the need for larger warheads to boost the payload sizes of future SLBMs, with increased accuracy forming an important yet still somewhat secondary consideration.

As this chapter will show, weapons designers negotiated tradeoffs between missile accuracy and warhead yield in ways that took account of and sought to leverage the changing political preferences of civilian administrators in OSD. For Navy missileers, evolving characterizations of accuracy and its attendant strategic implications over the course of the 1960s were bound up with concerns surrounding the programmatic autonomy and longevity of the fleet ballistic missile. Survivability – vulnerability's obverse – became the watchword for advocates of a broad range of often conflicting technopolitical agendas, with claims of enhanced "damage-limitation" capabilities ever more frequently invoked as a means of bolstering prior system justifications focused on addressing perceived system vulnerabilities. The increasing imbrication of counterforce and assured destruction rationales in system proposals and mission requirements in many ways set the stage for the subsequent decade's overt turn to a war-fighting nucleare posture.

The high-profile declaratory shift in U.S. nuclear targeting policy heralded by the Schlesinger Doctrine, first promulgated in January 1974, and crystallized in Jimmy Carter's 1980 Presidential Directive 59 appeared to many contemporary arms controllers outside the Nixon administration to be a betrayal of the ongoing negotiations with the Soviet Union.[201] Placing this apparent pivot in U.S.

[201] April Carter, *Success and Failure in Arms Control Negotiations*, (London: Oxford University Press, 1989), 141.

strategic policy in a longer historical perspective requires understanding the formative processes by which technical communities proactively invested weapons systems and related lines of R&D with multiple strategic meanings in the seminal years leading up to the commencement of bilateral U.S.-Soviet arms control talks. In the case of Navy programs in particular, maintaining a degree of plausibility with respect to the fulfillment of counterforce mission priorities presented as vital a political imperative as maintaining the FBM's traditional reputation as a retaliatory weapon. For reasons this chapter will explore, pressure from procounterforce segments of the defense establishment prompted Navy administrators of strategic weapons systems to support counterforce-oriented lines of R&D even as they resisted characterizations of the sea-based ballistic missile as playing an explicitly counterforce role in the national nuclear strategy. Moreover, and crucially, contemporary efforts to develop and deploy faster, quieter, "more survivable" submarines meant that congressional and nongovernmental observers often dubbed certain areas of research counterforce-enabling when connected to missile programs and survivability-enhancing when undertaken in the course of submarine "modernization." Over time, the political task of ensuring a continuation (and gradual expansion) of Navy funding for R&D activities geared toward producing smaller, more maneuverable, and more accurate missiles laid the groundwork for a broader reconceptualization of what defense officials considered to be the necessary technological pillars of a counterforce posture by the early 1970s.

Origins of a Countermeasure: Multiple Warheads and Survivability

In piecing together the contingent history of what have since come to be understood as counterforce technologies, this chapter focuses centrally on the relationship between Navy-sponsored work on advanced submarines and the broader national military establishment's growing interest in the development of MIRVs, or multiple independently-targetable reentry vehicles, over the course of the first half of the 1960s. Arguably the most controversial technological development of the nuclear age, MIRVs in the decades since their deployment have acquired a strategic reputation that remains at odds with that of its earliest portrayals by the technical communities that first designed these systems. That is, far from being the counterforce weapons on which later observers would pin hopes of operationalizing a nuclear war-fighting strategy, missile designers actively characterized MIRVs throughout the first decade of their development as solutions to the problem of warhead vulnerability.

First conceived in the immediate aftermath of the launch of Sputnik, amid the U.S. defense establishment's frenzied rush to the drawing board of future weapons, the military R&D community considered multiple warhead systems to be just one out of many potential countermeasures for emerging Soviet developments in strategic forces. Public portrayals of multiple warhead technology as the most effective response to contemporary perceptions of growing Soviet anti-ballistic missile (ABM) capabilities circulated across a wide range of forums, from congressional testimonies to newspaper accounts. Such narratives, in their reliance upon the taken-for-granted projections of future ABM deployments, leveraged long-standing concerns around warhead vulnerability, and were deployed early and often in support of follow-on generations of strategic missile systems. R&D

personnel responsible for managing first-generation missile programs such as Polaris recognized the technopolitical affordances offered by frames of vulnerability and moved to capitalize on these affordances in order to secure and maintain the financial, bureaucratic, and doctrinal backing necessary to ensure these programs' longevity.

Understanding the ways in which program officers and their collaborators in industry and academia negotiated the changing politics of vulnerability in the years leading up to the first round of U.S.-Soviet arms limitation talks sheds light on the historical processes that underpinned early arms controllers' imaginations of which categories of weapons could feasibly be limited by international agreement. This chapter thus further interrogates the circumstances under which early postwar naval R&D in the areas of warhead miniaturization, solid fuel propellants, and guidance and navigation systems created opportunities for Navy officials to overcome opposition from various quarters of the Navy Department to follow-on Polaris systems and expand the program's base of support within the Pentagon and on Capitol Hill. In foregrounding the work of technical communities in constructing malleable representations of MIRV-relevant programs, this chapter serves to highlight the role of scientists, engineers, and Navy officers in prefiguring the counterforce turn in the military imagination of MIRV systems.

Taking place alongside 1960s era work on multiple warhead systems, contemporary ASW R&D was predicated on analogous yet less readily visible fears of system vulnerability, given the fact that, in the case of advanced submarines, the platforms themselves constituted admissible – and often, the only readily available – evidence of their own susceptibility to potential countermeasures. The question of submarine survivability stemming from advances in ASW drew far less public scrutiny

than the perceived threat posed by contemporary ABM deployments, in large part due to the Navy's successful public relations campaign to characterize the nuclear submarine as the most survivable basing mode for nuclear weapons. Nevertheless, claims about the projected vulnerability of Polaris submarines served a number of distinct interests throughout the defense establishment, at times in furtherance of programmatic ends unrelated to the Navy's fleet ballistic missile program. A central thread running through this chapter thus takes up the question of how these claims about the future susceptibility of U.S. submarines to ASW circulated in the context of competing programs of strategic weapons development. Contemporary Air Force and Army developments in long-range solid-fuel missiles and ABM contributed to a political environment in which claims about an approaching era of submarine vulnerability were made foundational to building and maintaining these programs' base of support within the Pentagon.

Simultaneously, growing interest among Navy leaders in securing a formal counterforce mission for the sea-based ballistic missile force had by the mid- to late-1960s prompted some observers, writing in the context of imminent or ongoing U.S.-Soviet arms control negotiations, to draw attention to the existing counterforce potentialities of ASW. However, despite this heightened level of public scrutiny brought on by the advent of formal diplomacy on matters of strategic forces, the ASW mission by and large escaped this period without defense officials or arms controllers painting it with the counterforce brush. Unlike MIRVs, which by the early 1970s U.S. audiences understood to be counterforce-enabling technologies, ASW emerged from the first round of arms control talks as an all but explicitly protected category of R&D. This chapter thus interrogates the ways in which technical communities and their interlocutors narrativized continuing work on ASW amid a growing pitch of

public controversy over the strategic and political implications of weapons systems designed to target Soviet forces.

Throughout the course of the developments explored in this chapter, narratives of vulnerability circulated across and beyond the confines of the U.S. defense establishment. As the prospect of arms control drew nearer, and high profile weapons systems provoked ever more public confrontations with congressional and popular audiences, weapons designers' talk of future vulnerability featured centrally in the rationales of every major new development in strategic forces, from anti-submarine warfare, to multiple warhead technology, to missile defense. Perhaps no other weapons programs benefitted as materially from widely accepted claims of approaching vulnerability than those charged with developing MIRVs and new techniques and instruments of anti-submarine warfare. As in previous chapters, I pay special attention to those sites, actors, and institutional relationships which made explicit the sorts of technopolitical affordances that MIRV and ASW systems (as survivability enhancements) appeared to offer to the various communities engaged in their realization, or, in the case of arms control, their rational management, according to the dictates of the freshly formalized logic of academic nuclear strategy.

The final section of this chapter turns to the earliest years of U.S.-Soviet strategic arms limitation talks (SALT) that took place between November 1969 and May 1972, in order to examine the ways in which arms control served to freeze formerly fluid narratives regarding the strategic character of emerging weapons systems. The signing of the Interim Agreement and the ABM Treaty in May 1972 set down the first internationally-recognized limits on strategic weapons, even as they stopped well short of arresting progress on weapons programs then under development, particularly

those geared toward producing more accurate MIRVs and more sophisticated ballistic missile submarines. This chapter thus traces the ways in which proponents of R&D in these areas both reactively and proactively attempted to shape popular conceptions of the strategic implications of this ongoing work, with the result that certain channels of R&D found themselves not only insulated against regulatory efforts by arms controllers, but bolstered by them. This chapter concludes by drawing out the structuring effects of the foregoing two decades of military R&D on contemporary understandings of the appropriate goals, scope, and mechanisms of arms control.

From A3 to B3: MIRV and the FBM

In early February 1961, three years prior to his chance encounter with Brown on the steps of the Pentagon, Marvin Stern had gone to Omaha. There, at SAC HQ, he was briefed alongside fellow incoming DOD appointee Robert McNamara on the military's latest nuclear targeting plan for general war, SIOP-62, slated to go into effect on July 1. The plan provided for a minimum option of launching the 1,706 weapons that made up the national strategic nuclear alert force as quickly as possible against 725 targets, with a projected death toll exceeding 200 million across the USSR, Eastern Europe, and China.[202] According to a 1987 interview, Stern indicated that the experience prompted him, together with colleagues Alain Enthoven and William Kaufman, to persuade McNamara to adopt

[202] William Burr, "U.S. War Plans Would Kill an Estimated 108 Million Soviets, 104 Million Chinese, and 2.6 Million Poles: More Evidence on SIOP-62 and the Origins of Overkill," *UNREDACTED* (blog), November 8, 2011, https://unredacted.com/2011/11/08/u-s-war-plans-would-kill-an-estimated-108-million-soviets-104-million-chinese-and-2-3-million-poles-more-evidence-on-siop-62-and-the-origins-of-overkill/.

> a strategy of "controlled response" [in which the] first priority would be to blunt an enemy's capability for strategic nuclear strike against you. There would be a graded response against his additional military, war-fighting and industrial capability. Finally, and only as a last resort, there would be the destruction of his cities together with the attendant large civilian casualties.[203]

Stern's formative brush with the existing state of nuclear war planning left him with an abiding impression that the more accurate U.S. weapons became, the more "controlled" – that is, the less catastrophic – the available U.S. nuclear options would be in any future war scenario. A strong proponent of weapons programs designed to support a counterforce targeting doctrine, Stern and a growing number of his colleagues at OSD considered accuracy the most critical component of next-generation strategic systems. And despite the best efforts of top Navy officials like Admiral Arleigh Burke to brand sea-based systems as a retaliatory force committed to a policy of assured destruction, Navy programs proved by no means exempt from pressure from civilian planners to produce more accurate missile systems–a pressure that would only grow over the course of the Kennedy-Johnson administration.

In fact, scrutiny along these lines came from more than one direction. Burke's retirement in August 1961, after serving a record three terms as Chief of Naval Operations (CNO), opened up space within the admiralty for counterforce proponents to push for a greater Navy investment in what they considered to be counterforce-enabling lines of R&D. Additionally, the appointment of Paul H. Nitze in November 1963 to the post of Secretary of the Navy did much to aid the pro-counterforce agenda

[203] Spinardi, *From Polaris to Trident*, 220.

from the civilian side.[204] Early on into his tenure as Secretary, Nitze established the so-called "Great Circle group" for the purposes of analyzing long-range strategic issues, selecting Rear Admiral George H. Miller to serve as its first chairman.[205] The group soon became the center of pro-counterforce sentiments within the Navy, and exerted its influence on matters ranging from high-level plans and policy to the operating requirements that would shape the capabilities of future naval weapons.

Topping the list of design features these and other advocates of counterforce planning within the Navy strove to optimize was – initially – not accuracy, but yield. Since the beginning of the debate over postwar U.S. military strategy, the level of fierce inter-service conflict that continually plagued the question of roles and missions seemed to set the stage for each of the military branches to attempt to carve out as differentiated a niche as possible for their respective programs. To be sure, such attempts at differentiation were part and parcel of the initial campaign to develop, and subsequently, to maintain control over, the Fleet Ballistic Missile program for the Navy.[206] However, even as planners within each of the services strove to characterize their programs as fulfilling a unique set of strategic requirements, the underlying assumptions about the technological demands imposed by these

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[204] Already a known figure within national security circles, Nitze was formerly Director of Policy Planning at the State Department during the Truman administration. While serving in that role, Nitze famously authored National Security Council Paper 68 (NSC-68), which recommended that the administration embark on an immediate and massive buildup of U.S. conventional and nuclear military capabilities, including the pursuit of the hydrogen bomb. Presented to Truman in April 1950, NSC-68 did not obtain the presidential signature until after the outbreak of the Korean War, a conflict which served to cement political support for the unprecedented levels of peacetime military spending called for by the report. See "National Security Council Report, NSC 68, 'United States Objectives and Programs for National Security'," April 14, 1950, History and Public Policy Program Digital Archive, US National Archives. http://digitalarchive.wilsoncenter.org/document/116191.

[205] Ted Greenwood, *Making the MIRV: A Study of Defense Decision Making* (Cambridge, MA: Ballinger, 1975), 22.

[206] Harvey M. Sapolsky, *The Polaris System Development: Bureaucratic and Programmatic Success in Government* (Cambridge, MA: Harvard University Press, 1972), 44.

requirements were largely shared and uncontested prior to the early 1960s. More specifically, there was throughout the first two decades following the development of intercontinental range ballistic missiles a consensus that high-yield thermonuclear warheads were the only type of payload that could make the ICBM an effective counterforce weapon.[207]

The members of Nitze's Great Circle group by all accounts subscribed to this way of thinking, one that still dominated planning circles in both the Navy and the Air Force, and leaned heavily on SPO personnel to adopt larger, heavier warheads with greater yields to give the FBM a greater "hard-target-kill capability."[208] In the interests of preventing further encroachments on the program's autonomy, FBM designers strove to defuse, rather than counter head-on, the high-level push from Navy leaders to develop bigger warheads in support of a shift toward counterforce planning. As noted in chapter 3, each generation of the Polaris missile and the various warheads considered for its development were routinely evaluated for their projected effectiveness against military targets. This long-demonstrated concern for determining the workability of the FBM for counterforce targeting afforded designers the opportunity to craft and refine new arguments regarding what kinds of attributes formed the necessary ingredients in the making of a counterforce weapon.

Central to these arguments was the idea that whatever a warhead lacked in yield, the broader system could make up for in accuracy without an overall loss in effectiveness. Thus, SPO personnel claimed that even relatively "low-yield" warheads could serve as acceptable components of a counterforce system, so long as they could be delivered with sufficiently high accuracy to ensure they

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[207] Greenwood, *Making the MIRV*, 37-38.

[208] MacKenzie, *Inventing Accuracy*, 261; Spinardi, *From Polaris to Trident*, 91-92.

could produce the required level of damage against the types of military targets envisioned by war planners.[209] When, in the mid-1960s, the civilian R&D administrators at OSD joined top Navy leaders in pushing SPO to give the next FBM a greater capability against military targets, program leaders cooperated in ways that ultimately preserved and maximized their independence in the design process.

As will become clear in the move from the Polaris A3 to the fully-MIRVed Poseidon missile, SPO personnel and their contracting partners had to remake the assumptions of military and civilian planners to accept an altogether new approach to operationalizing their counterforce aspirations – one that abandoned a commitment to building large multi-megaton weapons in favor of smaller highly accurate systems. Effecting this transformation was the work of many years for FBM designers, proceeding in fits and starts as opportunities to change course and deviate from the letter of design goals imposed by officials from outside the program presented themselves. The Kennedy-Johnson years brought far more oversight to bear on the FBM program, a reality which was by no means unique to any big-budget R&D effort that came across the desk of the cost-conscious former business executive and Defense Secretary under both Presidents Kennedy and Johnson, Robert S. McNamara.

Even in light of the novel political environment brought on by the new decade, the position that SPO personnel found themselves in circa midsummer 1964 was an unfamiliar one. In May of that year, DDR&E Harold Brown ordered the SPO team to take part in a joint development of the Air Force-originated Mk 12 reentry body. Much of the office's success in managing the first three

[209] Though the Poseidon missile was ultimately assigned to the same targets as the Air Force's larger-yield Minuteman III, Air Force officers detailed to the Joint Strategic Target Planning Staff in Omaha reportedly taunted their Navy colleagues over Poseidon's 40 kiloton warheads, calling them the Navy's "firecrackers." Quoted in Spinardi, *From Polaris to Trident*, 112.

generations of the FBM — widely heralded in the subsequent scholarly literature — depended on the large degree of autonomy SPO leadership had exercised in defining, in-house, the operational requirements of the Polaris force. Initiating a follow-on program in the McNamara Pentagon, however, would prove to be a very different process altogether than during the twilight years of the Eisenhower administration, when the previous FBM development was authorized. SPO personnel designed the Polaris A3, initiated in 1959, to carry a three-body "cluster-type" warhead as a means of heading off criticism from Capitol Hill regarding the system's susceptibility to future Soviet ABM deployments. Nevertheless, the program encountered numerous difficulties as it worked its way through the civilian ranks of the Pentagon. The systems analysts staffing the offices of the Director of Defense Research and Engineering and the Secretary of Defense presented a particularly persistent obstacle. As late as 1962, three years into the A3 development, SPO had yet to obtain DOD approval of its novel design concept.

Having selected the three-body cluster principally for the flexibility it would afford Navy planners in finding a defensible rationale for the A3, SPO personnel were dismayed to meet with significant pushback on their preliminary designs for the missile's unique payload.[210] The primary challenge lay in demonstrating, analytically, that the separation between the three reentry bodies upon descent would be sufficient for at least two of the warheads to penetrate the expected ABM barrage

[210] The SPO team had endeavored to make the new RV so flexible, in fact, that it would be capable of delivering all manner of alternative payloads. As Lieutenant Commander Wertheim put it in a steering group meeting, "the reentry body system could be used for other than a vehicle for thermonuclear components. Both bacteriological and chemical warfare agents could be transported if this requirement should be established." See *Proceedings of the Special Projects Office Steering Task Group: TASK II--Monitor and Sponsor the Fleet Ballistic Missile Development Program*, Fourteenth Meeting, 3 September 1959, 7.

and detonate on target. The trouble with meeting this specification, however, was the tradeoff that increasing reentry body separation seemed to incur in what Polaris designers termed "system effectiveness" – that is, in the overall level of damage that the weapon would effect upon the target complex.

In the initial slate of design studies commissioned by SPO during the late summer and fall of 1959, the cluster had performed poorly in comparison with a single body reentry vehicle carrying a large-yield warhead when aimed at hardened point targets. While Navy leaders had already widely sold the Polaris weapon as part and parcel of the Navy's declared cities-only strategy of "minimum deterrence," a number of highly placed members of the design team remained dissatisfied with the prospect of producing a weapon with such little apparent utility against military targets, regardless of the political advantages anticipated by program leaders.[211] As time passed, and the national nuclear target list came under the centralized control of the Strategic Air Command (SAC) headquarters in Omaha, there arose substantial uncertainty on the question of just what kinds of targets the Polaris force would be tasked with destroying in the event of a shooting war. On September 20, 1962, at a meeting of the Polaris Steering Task Group, the head of the Reentry Body Committee Commander A. Julian commented on the likely response he expected DOD would give on the latest design study SPO had forwarded for a potential A3 cluster weapon, stating that:

> The current feeling in the Pentagon about this study is that perhaps the cluster is not the only configuration that should be used in the A3a or POLARIS follow-on systems. One of the reasons for this opinion is the fact that POLARIS is the primary protected reserve force and is being considered for any and all options of the SIOP. To be used

[211] Commander Paul H. Backus of the Office of the CNO was a particularly vocal advocate of retaining some capability against hard targets. See Ibid., 4-15.

> with a pre-empt option or as a primary protected reserve system, it must be capable of interdicting all kinds of targets and not be limited to urban-industrial sites only. The effectiveness of the cluster against the hard point targets is not very good with the present pattern and the feeling is that with some improvement in the accuracy of the system, a single, high-yield warhead would be more effective.[212]

Concerns about what would go into the A3 nose cone and what it meant for the missile's ability to menace hard point targets thus militated against more hypothetical anxieties over potential future countermeasures, the likelihood of which was still a point of ongoing debate and skepticism within SPO by late 1962.[213] Faced with pressure to return to a single higher-yield warhead design, members of the Reentry Body Committee recommended that the program undertake a comprehensive feasibility study of the single warhead and multiple warhead A3 variants then under consideration. The committee further suggested the possibility of fielding a "mixed force" of A3a clusters (for both defended and undefended urban industrial targets) and A3a single warheads (for hardened military targets) in order to enhance system "flexibility." In addition, committee members speculated about the possibility of "using one of the warheads to carry penetration aids and firing the other two at the target…to increase hard target effectiveness."[214]

Furthermore, such attempts to reconcile conflicting demands on system requirements took place within a policy environment dominated by uncertainty at the level of R&D and force planning. Later in the same meeting, in response to a contractor representative questioning whether it was "still

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[212] *Proceedings of the Special Projects Office Steering Task Group: TASK II--Monitor and Sponsor the Fleet Ballistic Missile Development Program*, Thirty Third Meeting, 20 September 1962, 57.

[213] Ibid., 57-75.

[214] Ibid., 57-59.

the philosophy of the POLARIS system to provide deterrence against urban-industrial targets," SPO Technical Director Levering Smith responded by saying:

> I do not know if that can be answered because one of the problems in trying to design and program these systems is that none of the Services has been assigned any particular portion of the over-all deterrent mission. The problem has not been resolved because there has been no decision within the Administration. I just keep guessing about it and sending in various proposals to see what happens. If we keep on doing this long enough, we can deduce what the assignment has been.[215]

The ambiguity Smith described as a feature rather than a bug in terms of how the Polaris weapons system fit into the overall context of national policy drew little response, and still less surprise, from those in attendance. One member of the group, however — Livermore scientist Kenneth Bandtel — spoke up to express his misgivings regarding the trial-and-error approach Smith had thus far taken to ascertaining the nature of the Polaris mission, a tactic Bandtel considered unnecessarily time-consuming. He went on to state that:

> I would like to refer to a meeting last week where Captain Thurmond from Op 60 [Strategic Plans Division, OCNO] expounded at some length on the flexible response policy and indicated that the capability of a pre-emptive strike was in these options. He indicated that his understanding was that this was at least Navy policy, and I am not clear whether he suggested that it was national policy. I would like to ask about this because it has a profound effect on the direction that the development of an A3 or an altered front-end A3a should take.[216]

Bandtel did not get a clear response to his question, for there was apparently none to be had, as one Captain F. J. "Fritz" Harlfinger interjected to point out that "of all the missile systems that were supposed to be ready, POLARIS is the only system that is really ready," clarifying that the Navy's

[215] Ibid., 75.

[216] Ibid.

"strike missions…are a mixture of IBM [intermediate-range ballistic missile], ICBM, POLARIS, and MINUTEMAN missions…because they are still waiting to make sure that the systems are going to be as effective as POLARIS." What this meant, he concluded, was that the Navy "is in a position of providing DOD with an assortment of warheads and missiles, all based on sea-based deterrence."[217]

Also present at the meeting was Harlfinger's fellow submariner Captain Richard B. Laning, then commanding officer of the submarine tender *Proteus*, the first tender to be converted for use specifically by Polaris missile submarines.[218] In response to his friend's observation, Laning took the opportunity to comment that he "was very much impressed by the tremendous advantage POLARIS offers in flexibility of targeting" as compared to SAC weapons.[219] Thus, the putative technological limitations of the Polaris for counterforce missions notwithstanding, exchanges such as these demonstrate that operational understandings of what missions the Polaris system was capable of fulfilling reflected a much wider range of possibility than the declaratory stance of the Navy would suggest.

The claim that the Polaris was the only missile system that was "really ready" was likely made, in part, in reference to the Air Force's recent discovery that the first batch of Minuteman I missiles – scheduled to deploy the following month – had all come with a defective first stage, limiting the system's range to 4300 miles instead of the expected 6300 miles, and forcing a subsequent change of

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[217] Ibid.

[218] Norman Polmar, "Norman's Corner: A Most Unforgettable Character," Naval Historical Foundation, March 27, 2014, https://www.navyhistory.org/2014/03/normans-corner-a-most-unforgettable-character/.

[219] *Proceedings*, Thirty Third Meeting, 20 September 1962, 77.

basing arrangements to ensure the missiles could still reach their programmed targets.[220] Beyond its basis in the logistical realities then facing nuclear planners, Harlfinger's contention that SAC targeteers were assigning the Polaris system to "fill in" for the targeting missions of an Air Force weapon deserves unpacking in terms of its implications for the kinds of operational considerations FBM designers routinely took into account. This comment underscored the sense of indeterminacy present in Smith's original admission that he himself was still guessing "what the assignment has been" for the Polaris program. Bandtel's confusion as to the character of Navy policy was thus symptomatic of a genuine lack of definitive guidance from above pertaining to the overall strategic goals intended, presumably, to guide the technological trajectory of the FBM development.

In response to his fellow officer's attempt at providing clarification, Smith reiterated that "the problem, however, still comes down to making a proposal and guessing whether it is going to be accepted," adding that "there are no guidelines."[221] Of course, these guesses needed to be educated – in the sense that proposals, when they were submitted, typically followed in the wake of pointed design studies demonstrating the desirability of pursuing a particular technical pathway. Conversely, such studies just as often fulfilled the goal of undermining prospective design choices that were not favored by program personnel or their principal contractors. To this end, the feasibility study suggested by the task group's reentry body committee was primarily geared toward persuading OSD administrators

[220] John C. Lonnquest and David F. Winkler, *To Defend and Deter: The Legacy of the United States Cold War Missile Program* (Washington, DC: Legacy Resource Management Program, 1996), 243.
[221] *Proceedings*, Thirty Third Meeting, 20 September 1962, 75.

who remained skeptical of SPO's proposal for a multiple warhead design for the A3.[222] The fight to keep hold of the cluster design that program officials believed would provide the greatest degree of political cover in the ABM debate presumed to be in the offing proved formative. While SPO successfully brought the A3 through to deployment in September 1964 (having preserved its multiple warhead design), the initial proposal for the follow-on Polaris A3a, soon to be dubbed the Polaris B3, quickly came back with a negative answer from OSD.

By early 1963, pressure from counterforce advocates within the defense establishment had mounted to the point where any A3 follow-on system would need to build a credible case for how it proposed to take meaningful steps toward achieving such a capability. At the time, this meant, effectively, going with a high-yield single warhead reentry body over a smaller multiple warhead reentry vehicle (RV). For the purposes of SPO personnel and their industry contractors, reckoning with this reality took evolving a long-term strategy of adaptation, and not only with respect to the pro-counterforce political environment. Polaris designers, in particular those hailing from the national laboratories and the lead system contractor Lockheed, over time took proactive measures to reshape dominant assumptions regarding what configuration of system parameters constituted a "counterforce capability." In effect, the adaptation went both ways – SPO personnel dutifully pursued lines of R&D dictated by their superiors in the Navy and civilian hierarchy, but at the same time, they pursued the preferred technical avenues of their own members, on their own initiative,

[222] When justifying the committee's recommendation for a formal study, Julian noted that "since people in the Pentagon are indicating interest in the single warhead, we are going to have to state facts to back up our preliminary design." *Proceedings*, Thirty Third Meeting, 20 September 1962, 59.

while crafting new (and revising old) justifications for sustaining these ventures, tailored to the increasingly counterforce-oriented R&D agendas of military and civilian planners. In other words, FBM designers accepted top-down guidance on system requirements, but in response reshaped narratives about the technical capabilities required to fulfill those requirements.

An illustration of this dynamic can be seen perhaps most clearly in the way in which SPO personnel navigated the long road to determining what would be the character of the payload that would sit aboard the next iteration of the FBM. Many years after the fact, Rear Admiral Robert H. Wertheim, who until 1962 had chaired the steering group's reentry body committee before serving a stint in the office of the DDR&E, summarized the general attitude of the SPO team toward accepting a greater stake in the counterforce mission in the design of the new missile (soon to be renamed Poseidon):

> Most of us saw the role of Poseidon as not different from the role of its predecessors, namely providing an absolutely dependable, reliable deterrent, and most of us were sceptical about the need to dig out hard targets as an essential element of deterrence. We went along with it to the degree necessary to keep the program. The nature of democracy…is that you're constantly making compromises with conflicting constituencies, and we had to serve the reigning constituency even if we, sometimes we felt they were a little nutty.[223]

What Wertheim meant by "an absolutely dependable, reliable deterrent" was a missile capable of fulfilling the objective that Navy officials had long endorsed, that is, threatening cities with attack from the sea in retaliation against a first strike on the United States. And although Wertheim clearly did not think much of the (by his estimation,"nutty") strategic reasoning behind the demands of

[223] Interview by Donald MacKenzie, 4 March 1985. Quoted in Spinardi, *From Polaris to Trident,* 86.

counterforce advocates, his acknowledgment that they formed "the reigning constituency" attested to system designers' fundamental agnosticism on the question of what the systems they designed were ultimately for. Admiral Galantin, the new head of SPO, put this point most succinctly during the same September 1962 meeting when he stressed the importance of "not only flexibility of hardware, but flexibility in thinking" to the task of keeping the FBM program intact and competitive in the context of contemporary strategic weapons systems.[224] Galantin further provided an instructive anecdote to underscore his meaning:

> I remember a few years ago I went to the blackboard and tried to convince some of you that 16 [launch] tubes was enough, and ever since, Bill Whitmore [former SPO chief scientist] has been telling me that is the best job he ever saw of throwing a dart and then drawing a bullseye around it.[225]

The next bullseye to be drawn would need to encompass enough of those "conflicting constituencies" – each advancing seemingly contradictory imaginations of the FBM and its role in the national nuclear strategy – to keep the program running. If Navy leaders wanted greater yields, and OSD wanted higher accuracies, and Congress wanted neither, SPO personnel reasoned that they would need to work out a creative technopolitical compromise if their follow-on program was to reach deployment. By the end of 1963, DDR&E Brown had ordered SPO to collaborate with the Air Force in the development of the Mk 12 RV, a multiple warhead system originally conceived for use aboard the Air Force-designed Minuteman II. Thus, despite the program having finally secured DDR&E authorization for a follow-on missile program at around the same time, a joint RV development with

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[224] *Proceedings*, Thirty Third Meeting, 20 September 1962, 85-86.

[225] Ibid., 84.

the Air Force presented a substantial loss of program autonomy. In addition, yet another Air Force warhead development, known as the Mk 17, was also being assessed for Navy use aboard the Poseidon by counterforce advocates highly placed within the service hierarchy, including the office of the CNO and Secretary Nitze's Great Circle group. The Mk 17 featured a heavy, multi-megaton warhead designed at Los Alamos, and as such it presented an ideal candidate payload for the Poseidon in the eyes of counterforce-minded Navy officials.

Neither the designers at SPO nor Lockheed were exactly content with the prospect of the Mk 12 or the Mk 17 ultimately being selected for the Poseidon RV. Given the joint (or in the case of the Mk 17, wholly Air Force controlled) nature of the programs, SPO designers feared the reputational consequences of fielding a missile whose most critical subsystems had not been optimized solely for the FBM mission and its unique operating environment. Additionally, Lockheed had designed both the Mk 1 and Mk 2 RVs that had flown aboard previous generations of the Polaris, and the company's work on reentry body development rivaled and may have even exceeded its role as the overall FBM system contractor in terms of overall profits generated.[226] Unsurprisingly, the Lockheed-designed Mk 3, featuring a much smaller 40-50 kiloton yield warhead designed by Livermore, was the RV concept preferred by both SPO and its lead contractor.

Not only would going with the Mk 3 preserve the longstanding technical and business partnerships that had been forged over the course of previous FBM developments, but its lightweight design moreover lent itself exceedingly well to flexible deployment as part of an overall MIRV

[226] Spinardi, *From Polaris to Trident*, 98.

configuration. By the mid-1960s, SPO's original justification for electing to pursue a multiple RV design for the A3 – namely, the political pressure expected to accompany revelations of Soviet ABM capabilities – was still very much in play, as program leaders frequently expressed concerns regarding the survivability of the existing FBM force vis-à-vis new exo-atmospheric ABM systems.[227] Unlike with endo-atmospheric intercept systems, U.S. planners assumed exo-atmospheric systems would be capable of destroying all three reentry bodies with one sufficiently high-yield burst detonated prior to atmospheric reentry, when the three warheads were still spaced relatively close together.[228]

Having fought to retain the three-body cluster design of the A3 over larger single-warhead variants principally to address these concerns, SPO leaders confronted with the possibility that the A3 could nevertheless be seen as vulnerable to exoatmospheric intercept sought to double down on the move toward larger numbers of small warheads for the next FBM. Nonetheless, despite this strong preference, SPO personnel first had to manage to reconcile the strong and disparate preferences of a number of key audiences to which they were accountable. Building a weapon that could pass muster with all of SPO's constituencies required reconciling strategic rationales that these audiences had only ever previously understood to exist in serious tension with, if not complete opposition to, one another.

While many have since pointed to the relative lack of practical difference between counterforce and countervalue targeting in terms of resulting casualties (as many military targets are

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[227] Several meetings of the SPO Steering Task Group featured discussions of RV susceptibility to exo-atmospheric intercept. For contemporary reactions to the deployment of the Galosh system around Moscow, see Spinardi, *From Polaris to Trident,* 72-74.

[228] *Proceedings of the Special Projects Office Steering Task Group: TASK II--Monitor and Sponsor the Fleet Ballistic Missile Development Program*, Twenty Ninth Meeting, 18 January 1962, 144.

geographically collocated with densely populated urban-industrial centers), the conceptual distance between damage-limitation (counterforce) and assured destruction (countervalue) as doctrinal categories has historically been a vast one.[229] Since the earliest postwar debates over U.S. nuclear strategy, the divide over whether to target cities or military installations formed arguably the most visible schism within the U.S. nuclear establishment, famously first drawing a national spotlight during the 1949 revolt of the admirals. However, this controversy would eventually obscure the degree to which U.S. nuclear war planning evolved to incorporate both counterforce and countervalue approaches in the formulation of the national target list.[230]

To be sure, the fact that this debate played out far more aggressively in the public sphere than in the classified reaches of the Defense Department does not mean that the matter of targeting, particularly as it related to the setting of weapons requirements, did not spark its fair share of conflict within and between the services. In the case of the FBM, Navy leaders went to great lengths to deny claims that the earliest generations of the Polaris system were meant to target anything but cities, precisely to ward off claims that the Navy was looking to pick another fight with the Air Force, which by the mid-1950s had become the most prolific generator of counterforce targets in the ever-expanding national war plan. Ironically, avoiding another fight with the Air Force in this instance

[229] To be sure, "damage-limitation" did not gain wide traction as an equivalent label for the counterforce mission until well into the 1970s. However, the term had been in circulation within the nuclear planning establishment since the late 1950s. For information on the early discursive evolution of the terms counterforce vs. countervalue, see George Herman Quester, "Counterforce, Countervalue; the Early History of a Distinction in Air Strategy, 1900-1945," PhD Dissertation, (Harvard University, 1965).

[230] David Alan Rosenberg, "The Origins of Overkill: Nuclear Weapons and American Strategy, 1945-1960," *International Security* 7, no. 4 (1983): 3–71.

meant publicly embracing a mission the Navy had openly reviled as morally indefensible less than a decade beforehand.

A decade following the creation of SPO and the FBM program, yet more reversals were in the offing. The most dramatic of these involved the far more rapid increase in the number of warheads deployed aboard Navy submarines than aboard new Air Force systems, due to the deployment of the multiple warhead A3 and its replacement of earlier-generation single warhead Polaris missiles.[231] Less visible, but no less significant, was the gain in accuracy of missile guidance and ship navigation systems which the Navy had a large hand in financing through its R&D investments. Navy-sponsored accuracy work, however, unlike Air Force efforts, had not been recognized or touted to offer advances in the counterforce capabilities of sea-based strategic systems. Instead, justifications for improving the guidance and navigation systems of the FBM had long been couched in the language of survivability.[232] When SPO finally did come under pressure to provide a greater capability against hard military targets, officials within the program became wary of external demands for yet further improvements in SLBM accuracy beyond the roughly 0.5 nm circular error probable of the A3.[233]

Despite these misgivings, a number of factors made it politically untenable for the SPO team to resist calls, especially from OSD, to improve FBM accuracy with Poseidon. By the mid-1960s, SPO

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[231] Robert S. Norris and Hans M. Kristensen, "Declassified: US Nuclear Weapons at Sea during the Cold War," *Bulletin of the Atomic Scientists* 72, no. 1 (January 2, 2016): 58–61.

[232] For a given set of guidance components, missile accuracy degrades as missile range increases. In light of this fact, accuracy improvements for Navy weapons were often justified on the basis of needing longer range missiles to increase the size of the patrol areas from which submarines could remain within striking distance of their assigned targets. With a larger swath of open ocean in which to operate, submarines could be made that much more difficult to locate and destroy for enemy ASW forces.

[233] Circular error probable (CEP) is a measure of the average miss-distance of a given missile system. A CEP of 0.5 nm can be expressed as the distance within which a missile will land 50% of the time.

had been twice subordinated within the ranks of the Navy hierarchy – from its privileged perch where it had reported directly to the Secretary of the Navy, the SPO team in 1963 came under the jurisdiction of the Chief of Naval Material, who was in turn placed under the jurisdiction of the Chief of Naval Operations in 1966.[234] Beyond having to answer to a greater number of Navy interests, SPO personnel further had to reckon with the fact that, for much of the uniformed Navy, the prospect of another follow-on FBM development was deeply unpopular. In short, SPO leaders were no longer in a position to dictate terms.

However, while their autonomy as an organization within the Navy had been much reduced, FBM designers managed to keep hold of at least one important aspect of the next missile's ultimate form: its operational (and interpretive) flexibility, which was not only a goal but a defining practice undergirding SPO's design philosophy. In the face of strong pressure to develop a system with some capability against military targets, FBM designers responded with initiatives aimed at producing the results being demanded while using the preferred institutional collaborations and subsystem components familiar to and selected by SPO personnel.

Showcasing the extent to which this emphasis on flexibility diffused throughout the Navy and the broader defense establishment, in March 1964 Secretary Nitze wrote a letter to Congressman George Mahon of Texas, in which he declared that the FBM offered "great flexibility in the way we can target and retarget our Polaris system, varying all the way from purely military targets to the urban industrial complex."[235] Slightly less than a year later, President Johnson's state of the union address in

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[234] Sapolsky, *Polaris System Development*, 198.

[235] Robert Thompson, "11 U.S. Subs could Kill 30 Million," *Boston Globe*, 3 March 1964.

January 1965 unveiled the administration's plan for building the Poseidon missile, a system he said would be capable of destroying "a broader range of possible targets and give added insurance of penetration of enemy defenses."[236] In the weeks following Johnson's address, press accounts ran further coverage of Navy claims regarding the Poseidon and its future place in the overall nuclear strategy, most notably with regard to its ability "to target the smaller military targets."[237]

Concerns about the implications of accepting a more prominent counterforce role for the FBM quickly paled in comparison with the perceived risks posed by the joint-service development of the Mk 12, an effort which by early 1964 had already been riven by disagreements between Air Force and Navy representatives over a range of system design parameters, particularly on the issue of warhead vulnerability.[238] Thus, when Carl Haussmann of Livermore and Lloyd Wilson of Lockheed proposed the use of a smaller warhead – one that Livermore had earlier tried and failed to sell to the Air Force – the idea quickly caught the interest of SPO leaders eager to abandon the Mk 12. However, in order to secure the necessary approval from the Navy and the Pentagon for such a revision of the new FBM's performance requirements, a smaller warhead demanded a more accurate guidance system to effect the same planned degree of damage at a given target. SPO officers did not need to look far to find just such a system, as Marvin Stern's successful bid to keep Kearfott's stellar-inertial guidance program afloat presented FBM designers a timely means of garnering needed high-level support for its preferred smaller RV, the Lockheed-designed Mk 3.

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[236] Quoted in Greenwood, *Making the MIRV,* 6.

[237] "Late 1966 Test Target Set for New Missile," *Harford Courant*, 25 January 1965.

[238] The primary stumbling block was the Navy's much more stringent vulnerability requirements. See Buchonnet, "MIRV," 50.

To be sure, few at SPO actually favored the adoption of a stellar-inertial guidance system for its own sake, as previous generations of the FBM had incorporated acceptable improvements in accuracy through the incremental refinement of traditional techniques. The services of MIT's Instrumentation Laboratory, headed by the famed early proponent of inertial ballistic missile guidance Charles Stark Draper, had proven sufficiently reliable to create serious misgivings among SPO leaders about the prospect of taking on the design of a dramatically revised guidance configuration, regardless of the promised accuracy gains touted by stellar-inertial advocates. Nevertheless, such misgivings, coupled with the fraught implications of going for greater accuracy amid a rising pitch of debate over the merits of counterforce planning, were eventually eclipsed by fears of being forced to accept a reentry vehicle that could not be tailored to fulfill what SPO planners determined to be the FBM's unique operating requirements. Eager to buck the constraints imposed by its collaboration with the Air Force, by 1966 SPO had approached Lockheed, the lead system contractor for the Polaris and the Mk. 3 RV, to undertake a formal analysis of Kearfott's stellar-inertial guidance package and means of adapting the technology for use on the FBM.

The gambit ultimately worked. In October 1967, the DDR&E, then former Livermore director John S. Foster, Jr., revoked the requirement for a joint service compatibility from the Mk 12 program, clearing the way for the Mk 3 to be approved for use on the Poseidon C3.[239] What's more, the compromise SPO leaders had struck by accepting a qualitatively different guidance system was also rolled back, courtesy of the anti-counterforce sentiments then prevailing in Congress. The promises of

[239] Buchonnet, "MIRV," 63.

Kearfott designers eager to sell stellar-inertial guidance to the Navy as a means of improving the counterforce capability of the FBM backfired when, early in the Nixon administration, Defense Secretary Melvin Laird drew the scrutiny of counterforce critics in Congress by requesting to divert extra funding toward the accelerated development of a working stellar-inertial guidance system.[240] The program's high-profile promises of dramatically improved accuracy for the FBM were enough to provoke determined opposition on Capitol Hill, eventually resulting in the program's cancellation. Subsequently, SPO designers were free to return to the traditional all-inertial system developed by longtime collaborators at the MIT Instrumentation Laboratory for the Poseidon C3.

SPO's temporary flirtation with stellar-inertial guidance technology further accomplished the goal of terminating the Mk 17 program, at least insofar as it concerned the FBM. In order to prove that the heavy high-yield warhead would be unnecessary for the destruction of military targets, given the accuracy gains that would attend incorporation of a star-tracker into the missile's guidance system, SPO leaders commissioned a study to analyze the damage effects of using a small versus large warhead aboard a stellar-inertial system.[241] With both the Air Force-led warhead developments successfully eliminated from the running for the Poseidon payload, the usefulness of stellar-inertial guidance waned precipitously in the eyes of FBM designers, particularly as the difficulties of obtaining reliable star sightings became ever more clear.[242] Thus, when Republican Senator Edward Brooke of

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[240] Stockholm International Peace Research Institute, *SIPRI Yearbook of World Armaments and Disarmament, 1968/69* (Stockholm: Almqvist and Wiksell, 1975), 55.

[241] The study ultimately concluded that a stellar-inertial guidance system, coupled with the Mk 3, would in fact satisfy the requirements of a counterforce capability. According to one Lockheed engineer, "the reason that study was done was to kill the Mk 17." Interview by Graham Spinardi, 8 May 1987. Quoted in MacKenzie, *Inventing Accuracy*, 264.

[242] At the thirty third meeting of the SPO steering task group, the head of the fire control and guidance committee gave less than promising updates from recently collected data suggesting that corrections from star sightings may be prohibitively

Massachusetts and his fellow colleagues critical of military programs dubbed "counterforce" successfully pressured the Nixon administration into cutting off funding for stellar-inertial guidance in December 1969, practically no one in SPO counted it as a setback.[243]

The commitment to maintaining as much organizational autonomy and influence over the design process as possible amidst a denser, more competitive institutional landscape led SPO designers to prize the affordances of flexibility as a general approach both to weaving together seemingly disparate targeting philosophies and to navigating the shifting politics of the strategic debates then roiling the defense establishment. The move toward larger numbers of smaller warheads on the Poseidon versus the A3 – Poseidon could carry as many as fourteen roughly forty kiloton warheads – signified the earliest instance of a MIRVed "low yield" strategic weapons system having a publicly acknowledged counterforce role. Despite the official sanction of the C3 as providing a nominal counterforce capability, portrayals of the new FBM's strategic role in the public sphere fixated on its contribution to traditional cities-centered targeting by improving the system's overall performance vis-à-vis a potential ABM barrage.[244]

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difficult to obtain during the short window of time a candidate star would be in view. Also at the meeting, the head of the MIT Instrumentation Laboratory Charles Stark Draper commented on a presentation of recent tests of a star-tracker aid to the SSBN navigation system, repeatedly pointing out that "gyros were going to prove to be absolute instruments and work out better than the stars, particularly if it was necessary to look at the stars from the bottom of the atmosphere where they wave around by several seconds." *Proceedings*, Thirty Third Meeting, 37-41.

[243] Notably, advocates of stellar-inertial guidance learned from their mistakes with the Poseion program, and would soon get another opportunity to enroll the interests of a follow-on FBM program. When the time came to justify a stellar-inertial system aboard the Trident C4, advocates revised their previous answer, claiming that the increased accuracy would "enhance survivability." See MacKenzie, *Inventing Accuracy*, 274. For the congressional handling of this episode, see Alton Frye, *A Responsible Congress: The Politics of National Security* (New York: McGraw-Hill, 1975), 70.

[244] "First Pacific-Based Sub of Polaris Type Sent Out," *The Sun*, 27 December 1964.; Robert Thompson, "11 U.S. Subs could Kill 30 Million," *Boston Globe*, 3 May 1964.; "Test of Poseidon, Minuteman 3 Set: MIRV Launches to Begin Thursday, Despite Protest," *The Sun*, 11 August 1968.

As the 1960s were drawing to a close, the sense of imminence surrounding the prospect of bilateral arms negotiations revitalized talk of the strategic interrelationships between MIRV and ABM technology, as well as their joint implications for the ongoing arms race. While military planners and arms controllers alike adduced a variety of arguments as to the linked fates of these two classes of weapons systems, many of which figure prominently in historical accounts of U.S. nuclear weapons policy from this time period, the same could not be said of the role of anti-submarine warfare in driving both MIRV and ABM proponents to take the particular technopolitical courses they pursued in the years leading up to and spanning the first round of strategic arms limitation talks (SALT).

The following section takes up the question: how did contemporary understandings of ASW and the associated R&D priorities to which it gave form and urgency structure the political landscape in which ABM and MIRV proponents were pressing their respective arguments regarding their programs' likely consequences for the "stability" of the arms race and the nuclear balance writ large? Answering this question will require delving into the numerous sites at which claims around the future of ASW as a form of counterforce operations became tightly coupled to the fortunes of the land- and sea-based ballistic missile force.

Survivability and its Discontents: ASW and the ABM

The intimate and longstanding ties between the FBM program and the larger ASW community within the Navy were both strengthened and strained over the course of the 1960s. Just as Navy planners and weapons designers were divided over the accuracy, range, and payload

requirements of future sea-based missiles, the naval architects, shipbuilders, and submariners who would design and operate the next generation of ballistic missile carrying submarines were at times bitterly split over the types of system features which should be optimized in order for future ships to evade and detect the quiet, deep-running enemy submarines presumed to be in the offing. And just as SPO personnel had to navigate the political and strategic controversies that attended their design decisions, the submarine community, albeit in more subtle ways, was also forced to confront the reality that its disputes could not long remain internal amidst the highly polarized survivability debates that dominated national security discourses throughout the 1960s.

Since shortly after the end of World War II, U.S. Navy planners had pointed to two primary justifications for the need to maintain a large, "balanced" fleet capable of performing the anti-submarine mission.[245] The undersea threat to commercial shipping did in fact date back decades earlier, to the First World War, but by mid-century developments such as the snorkel and subsequently the nuclear-powered submarine exacerbated Western fears of having transatlantic sea lanes once again seriously threatened in the event of any future war. In addition to the protection of commercial shipping, the novel postwar threat of missile attack from the sea, eventually with nuclear warheads, emerged as another prominent rationale out of the flurry of interest in the subject of undersea warfare that attended the 1950s. Admiral Jerauld Wright, head of the Atlantic Fleet, put it this way in his February 1959 testimony before the House Appropriations Committee:

[245] The concept of the "balanced fleet" had since mid-century formed the ultimate force planning objective of the U.S. Navy, the achievement of which would yield a fleet with all the necessary component platforms across air, surface, and subsurface operations in appropriate proportion to one another. As is the case with many planning concepts, the "balanced fleet" remained always a distant, orienting goal, and never a reality.

> Every free nation borders on the sea. Every free nation depends on the heavy tonnages of cargo ships, transports and tankers for their economic maintenance in peacetime and military reinforcement and survival in war…The Soviet submarine fleet is designed for these specific purposes, to isolate North America from Europe, to prevent us from following up on the advantage of our atomic retaliatory operations, to prevent us from reinforcing Europe, to enable them to extend the Iron Curtain…and to plaster our eastern seaboard with guided missiles launched from submarines. Our task is to prevent this.[246]

Wright went on to clarify that no one particular component of the fleet could by itself be an effective anti-submarine system, stating that "the best antisubmarine weapon we have is the coordinate employment of all of our forces; that is, air, surface and submarines."[247] As discussed in chapter 2, antisubmarine warfare formed a central argument for the retention and expansion of the postwar U.S. fleet, in light of what ASW advocates argued were the unique demands placed on naval operations by the mission's logistical, technological, and tactical complexity, as well as the raised stakes presented by the advent of atomic weaponry.

While R&D in this area continually outpaced procurement, ASW proponents did succeed at setting in motion a feedback loop that would drive sustained technical efforts in this domain for years to come, with important ramifications for the increasing profile of the submarine platform within the national nuclear strategy. Creating a feedback loop of requirements entailed winning widespread acceptance of the claim that, with the projected introduction of nuclear propulsion poised to make submarines all but invisible to previous means of detection, U.S. submarines ought to serve as proxies for future Soviet systems, around which new countermeasures could be designed. By the time Wright

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[246] *Department of Defense Appropriations for 1960: Hearings before the Subcommittee of the Committee on Appropriations*, 86th Cong. 303 (1959) (Statement of Adm. Jerauld Wright, USN, Commander in Chief, Atlantic).
[247] Ibid., 309.

came before the House Appropriations Committee, the self-contained measure-countermeasure dynamic fueling (anti-)submarine R&D was sufficiently taken-for-granted for the admiral to declare that:

> The primary mission of our atomic submarines is for the destruction of other submarines, and their secondary mission is to teach our own submarines how to destroy that particular type of submarine.[248]

Each swing of the pendulum between measure and countermeasure rang up a steep price tag. The Navy's original FY 1960 budget request of nearly $18 billion was substantially reduced upon review by the Eisenhower White House.[249] Wright's fellow officer also testifying at the hearing, Vice Admiral William G. Cooper, Commander of the Antisubmarine Defense Force (an arm of the Atlantic Fleet), framed the costs of fulfilling the Navy's postwar mandate with the following pointed statement:

> I feel that it is up to the country to assess the threat posed by the Soviet ballistic missile submarine and decide whether we must spend all this money. If the threat is comparable to that which we faced with the manned aircraft, I think we have to expect to pay a price for defense comparable to what we had to pay for the SAGE [air defense] system.[250]

The direct comparison between the judged importance of the ASW mission and that of air defense presented a significant juxtaposition. The decade leading up to Cooper's testimony had seen proponents of a more aggressive ASW effort consolidate support within the Navy. Thus Cooper's

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[248] Ibid.

[249] *Department of Defense Appropriations for 1960: Hearings before the Subcommittee of the Committee on Appropriations*, 86th Cong. 315 (1959) (Statement of Vice Adm. William G. Cooper, Commander, Antisubmarine Defense Force, Atlantic).

[250] Ibid.; The Semi-Automatic Ground Environment (SAGE) Air Defense System, begun in 1951, by the time of its deployment in 1963, totaled more than the cost of the Manhattan Project. "SAGE: Semi-Automatic Ground Environment Air Defense System | MIT Lincoln Laboratory," https://www.ll.mit.edu/about/history/sage-semi-automatic-ground-environment-air-defense-system.

assertion that the ballistic missile submarine threat could (and by implication, should) be considered on a par with that of aerial bombardment marked a significant turning point for ASW advocates, who by the 1960s shifted their attention to audiences beyond the ranks of Navy leadership. Winning high-level political support for accelerating ASW R&D required navigating a fraught terrain of competing big-budget weapons programs. To this end, the stable alignment of interests that had long characterized the relationship between the FBM program and the broader undersea warfare community once again offered certain advantages, particularly in light of the political favor accrued as a result of the widely touted success of the Polaris program.

Just as ASW-minded officers and scientists had been among the first to throw support behind the concept of a submarine-launched ballistic missile, SPO personnel, once they'd been successful in bringing multiple generations of the FBM concept to fruition, leveraged their more established position within the Navy to push for greater investment in ASW. By 1962, meetings of the Polaris steering task group regularly featured discussions of new and varied proposals "to contribute to other problems that the Navy has, such as anti-submarine warfare."[251] In turn, it would become increasingly apparent that assumptions regarding the magnitude of the future ASW threat to the FBM would continue to generate new requirements and further follow-on developments for both missile and submarine systems. During a presentation of the systems appraisal committee on May 28, 1964, SPO's chief scientist John P. Craven reflected on the "milestone" represented by the recently-begun

[251] *Proceedings*, Thirty Third Meeting, 21 September 1962, 77.

operational tests of newly deployed Polaris missiles, and in so doing laid out the recursive logic that sat at the heart of the measure-countermeasure dynamic:

> If the Russians do not do anything to counter the threat posed by the POLARIS missile, then our responsibility in developing and producing a deterrent weapons system is finished. We will not need the B3 nor any other follow-on program. The DASO's [Demonstration and Shakedown Operations] are themselves an indication that we have reached the end of our development program, and this is a major milestone indeed. But the Russians will and are doing things to confront and counter the threat posed by our program…Our knowledge of what the Russians will do is limited but we do know that they can devote tremendous resources toward solving their problem of lessening our abilities to survive and to penetrate onto targets. This presents us with something of a dilemma in those choices we must make to prevent the decay of our weapon system dependability, for we must anticipate Russian events that will in turn change our chances of survival and penetration.[252]

The ironclad assumption that each iteration of the fleet ballistic missile would prompt a Soviet response of specially designed countermeasures was central to maintaining a strategic rationale for follow-on FBM developments. At the same time, however, almost paradoxically, Craven acknowledged that past studies had shown "that not until after tremendous advancements have been accomplished in ASW would we really have to give serious concern to the problem of SSB(N) vulnerability," causing the members of the systems appraisal committee to "minimize" their concerns on the issue.[253] At first glance, it appears difficult, if not impossible, to reconcile this conclusion with Craven's strong statement in favor of designing future systems around ever stricter ASW benchmarks. However, recalling SPO's long-standing faith in the eventual emergence of Soviet countermeasures in response to the Polaris system, the lack of an immediate threat to the operational survivability of the

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[252] *Proceedings of the Special Projects Office Steering Task Group: TASK II--Monitor and Sponsor the Fleet Ballistic Missile Development Program*, Forty Third Meeting, 28 May 1964, 275-276.
[253] Ibid., 278.

SSBN would have been unlikely to trouble a decade-old practice of organizing contemporary R&D and future weapons requirements around the assumption of a pressing ASW threat that was always in the offing.

Moreover, what Craven meant when he spoke of "weapon system dependability" was in fact quite specific. DDR&E Brown had defined this particular evaluation criterion as the sum of a system's survivability, reliability, and penetrability.[254] In other words, dependability was meant to assess the extent to which a given platform could be "depended upon" to deliver a weapon onto its assigned target. In the case of the ballistic missile submarine, the matter of dependability engaged considerations of multiple perceived threats to system effectiveness – namely, the "survivability" challenge emanating from Soviet ASW, and the "penetrability" obstacle arising out of projected Soviet ABM deployments.

Taking account of the record of FBM efforts on the latter front, Craven argued for the need to remain similarly vigilant and proactive in designing the front end of future system generations. Referring at one point to a series of missile tests designed to assess the distinguishability of decoys versus real warheads, Craven warned that the contemporary state-of-the-art in penetration aids still left much to be desired, and placed a premium on continuing work on multiple warhead designs:

> The A3 warhead concept was an early realization of the need for penetration capability, and in this I think we took a substantial and important lead which has been supplemented by a penetration aids package. *These developments appear to give us a satisfactory lead in maintaining penetrability, but the Soviet emphasis on defensive systems and man's ingenuity in design of intercept systems, together with the fact that a ballistic missile defense constitutes a common defense against our total strategic threat, point only to one conclusion: Our continuing efforts in penetration are mandatory.* As

[254] Ibid., 275.

> we look into this problem, any presumption that our decoys are inherently non-discriminable – which many of us thought – is quickly dissipated by even a cursory inspection of the radar records from Kwajalein and Trinidad. Only the most sanguine would ever say that the present decoys constitute a major addition to the penetration package; the importance of multiple warheads, active jammers and chaff is thus reinforced and the importance of the B3 with its increased payload is again strongly emphasized by the results of these tests."[255]

Two key points from Craven's remarks deserve special attention. First, recalling his earlier suggestion that a present advantage should not breed a lasting complacency in the domain of submarine survivability, Craven makes a similar move when he discounts the importance of the apparent lead that the U.S. had taken in the area of warhead survivability (or equivalently, penetrability). The continued focus on the susceptibility of either system – whether it be submarine or warhead – to "man's ingenuity in design of intercept systems" is one prominent indication of the extent to which R&D thinking revolved around the measure-countermeasure dyad. Second, Craven's strong stance that standard penetration aids such as decoys were inferior to the use of multiple live warheads was representative of views among SPO and Lockheed personnel that any future FBM ought to incorporate MIRV technology.

Furthermore, the justification for MIRVing the FBM was one squarely rooted in a narrative that took for granted the need for active measures to overcome a perceived vulnerability vis-à-vis Soviet ABM capabilities. Even in light of extant pressures from the offices of the CNO and the Secretary of Defense to make the next FBM more "counterforce," counterforce rationales did not figure prominently in SPO proposals to MIRV the B3. This reality also obtained in contemporary Air-Force-

[255] Ibid., 279-280. Emphasis added.

led MIRV developments, and counterforce proponents across both services regarded MIRVs as ill-suited to the task of destroying hardened military targets. This prevailing narrative within the national military establishment, that MIRVs offered simply a more assured means of destroying Soviet cities even when defended by an ABM shield, would not begin to shift until the end of the decade, when the start of formal arms control talks raised the specter of MIRVs as the ultimate counterforce weapon.

In the mid-1960s, however, survivability still dominated the pantheon of strategic objectives then being invoked by advocates of every major weapons system development, particularly those to be deployed at sea. Even naval surface forces, whose role in nuclear war planning had thus far been kept to a minimum out of widespread skepticism regarding their survivability, briefly became a site of revived hopes for deploying nuclear weapons atop carriers, which for many in the Navy still remained the service's premier strategic platform. In an October 1964 speech given before the Naval Reserve Association, Chief of Naval Operations David L. McDonald cited the results of a recent study on carrier survivability, which he claimed "satisfactorily prove[d], we believe, that this type of weapons system is very survivable."[256] What McDonald meant by survivable became more clear when he elaborated that:

> We all realize, of course, that vulnerability or survivability is a comparative thing and when we speak of vulnerability or survivability of any particular weapons system we must ask ourselves the question – compared to what? For carriers we must, of necessity, compare their vulnerability to that of a land-based field supporting the same operation.[257]

[256] "New Claims made for Subs, Carriers," *The Hartford Courant*, 11 October 1964.

[257] Ibid.

In asserting the "necessity" of comparison between carriers and land-based silos and airfields when evaluating the (historically, much-maligned) survivability of the former, McDonald was making visible and explicit the ways in which contemporary claims about survivability were by no means being advanced in a political vacuum. On the contrary, the first half of the 1960s saw a marked shift in the nature of the competition between the services' various weapons developments. Whereas a decade before Navy and Air Force projects had fought to carve out as differentiated a niche as possible within the context of the national nuclear strategy, by the mid-1960s the technological and doctrinal priorities of the services had begun to converge in a number of key respects, as both Navy and Air Force planners presented less than satisfactory forecasts of how U.S. forces would fare against projected Soviet defenses.[258] In the political climate created by these widely publicized anxieties over the vulnerability of U.S. forces, survivability became military officials' most frequently invoked, most contested metric for evaluating the "necessity" of future weapons systems. Conversely, an existing system's vulnerability provided a powerful grounds on which weapons designers based their requests for follow-on R&D initiatives.

One outgrowth of this trend, and at times a significant accelerant, was the explosion of systems studies aimed at devising ever more sophisticated means of addressing perceived standing vulnerabilities. The years between 1964 and 1967 saw a profusion of influential, multi-year-long

[258] One particularly striking example of this phenomenon can be seen in the Air Force's attempt to develop the Mobile Medium Range Ballistic Missile (MMRBM) for possible use aboard surface ships. Once a strident critic of deploying strategic weapons aboard surface ships on the basis of vulnerability concerns, the Air Force lobbied for the MMRBM to be considered as a competitor with the Polaris missile to be deployed as part of the proposed NATO Multilateral Force (MLF). See "Midrange Missile Eyed by Air Force: It Could Rival Navy's Polaris as Weapon for Surface Ships," *The Sun*, 8 March 1963.

studies examining a range of novel design proposals, all geared toward addressing the problem of survivability as it pertained to the variety of systems making up the U.S. nuclear arsenal. Some of these studies blurred the line separating the work of making systems less vulnerable to preemptive attack from the work of making systems more capable of preemptive attack themselves.

One such report on the state of U.S. anti-submarine capabilities – the result of a study conducted by the ASW Panel of the President's Science Advisory Council (PSAC) and published in August 1965 – painted a bleak picture of the U.S. Navy's existing efforts and future plans in the ASW realm. The reason for this poor assessment was, strikingly, the fact that "currently programmed (5 year) ASW forces would have extreme difficulty in denying to the Soviet Union a submarine-launched nuclear second strike capability which is a substantial augmentation of their land-based strategic nuclear forces," leading the panelists to conclude that U.S. ASW capabilities were, in fact, "very poor," particularly in light of related programs' $3 billion annual price tag.[259] Diagnosing the root causes of the inadequacy as "the scarcity of technical and scientific personnel in positions which carried real management responsibility and/or authority" and "policy which in effect gives excessive emphasis to quantity, to the relative neglect of quality...in force development."[260]

As a remedy, panelists recommended that the Department of Defense institute an analogous organizational structure to that of SPO for the job of managing the nation's growing ASW portfolio. The Navy's Special Projects team offered what many considered a model of program management

[259] Foreign Relations of the United States, 1964–1968, Volume X, National Security Policy, ed. David S. Patterson (Washington: Government Printing Office, 2001), Document 124.
[260] Ibid.

ideally tailored to the demands of bringing untried advanced weapons concepts all the way from design and development to procurement and deployment. While acknowledging recent steps taken by the Navy to improve coordination on matters relating to ASW, including the establishment of a Director for ASW Programs under the CNO, as well as a Manager of ASW Systems Projects under the Chief of Naval Materiel, the panel maintained that these positions nevertheless came with "inadequate staff and insufficient line authority" to operate as effective managers of the wide array of ongoing ASW efforts.[261]

In addition to organizational troubles, the panel accused the Navy of having devoted insufficient thought to the strategic justifications driving their current programs of development, stating in no uncertain terms that "the Navy should devote much greater efforts to the development of a rationale for the employment of ASW forces and of justification for its development and procurement programs."[262] That the panel thought little of the Navy's standing rationale of defense of convoy operations and commercial shipping, insofar as it was used to argue for greater *numbers* of ASW components, did not prevent the panel from recommending more funding be directed toward work on ASW – though, to be sure, for the purposes of accelerated R&D, the money for which would come at the expense of funds previously budgeted for procurement.

In fact, a unifying theme of contemporary studies charged with evaluating current and future military R&D was their shared emphasis on the need for qualitative rather than quantitative improvements in planned weapons developments, despite the expressed desires of both Navy and Air

[261] Ibid.

[262] Ibid.

Force leaders for substantial increases in force sizes. In general, civilian planners in the McNamara Pentagon were inclined to support such conclusions in the name of cost-effectiveness. What all of these formulas had in common was "the assumption that the Soviets will prepare for a preemptive counterforce attack against the United States," as the Institute for Defense Analyses' (IDA) STRAT-X report put it in 1967.[263] Understanding the work that this assumption was doing in terms of defining contemporary expectations of survivability requires homing in on the precise definitions at stake in the evaluation of survivability as a feature of U.S. strategic forces.

Crucially, these studies, which covered everything from missiles, payloads, basing systems, and associated countermeasures, understood the problem of survivability to mean systems' susceptibility to intercept and destruction. Notably, alternative understandings of survivability existed, and, arguably, traveled far more widely among non-technical audiences, namely those based on officially accepted claims of what percentage of attacking weapons need "survive" enemy defenses to inflict the desired level of damage. In this light, the assumption of a surprise attack that is always counterforce in nature – that is, which for planning purposes principally directs the full weight of attack against deployed forces – in effect welds these two definitions of survivability together, thus creating a sense of equivalence between a system's susceptibility to potential countermeasures and the broader arsenal's vulnerability to surprise attack. Remaining attuned to the persistent slippage between this definition of survivability and the system-centric definition used by technical communities is critical to

[263] Institute for Defense Analyses, Research and Engineering Support Division, *The STRAT-X Report, Vol. 1*, August 1967, 4.

understanding the enduring nature of the debate around the alleged vulnerability of U.S. nuclear forces that raged throughout the 1960s and beyond.

Certain participants in these debates did go on to articulate publicly the distinction between these definitions, and even further to point out the implications carried within the substantive distance separating these two understandings of survivability. One such participant, Harvey Brooks, then Dean of Engineering and Applied Physics at Harvard and longtime consultant to the Navy on matters of undersea warfare (as well as a prominent member of the aforementioned PSAC ASW panel), testified before the International Organization and Disarmament Subcommittee of the Senate Committee on Foreign Relations on May 16, 1969. Brooks had been called before the committee in large part to respond to the suggestion, made earlier that spring by Secretary of Defense Melvin Laird, that the survivability of Polaris submarines during the period beyond 1972 was very far from assured.[264] Having cast doubt on the future of what was widely considered the most invulnerable segment of the U.S. nuclear arsenal, Laird's comment provoked a flurry of congressional interest on the contemporary state of the art in anti-submarine warfare, and whether U.S. submarines did in fact stand at some risk of falling prey to new instruments and techniques of undersea warfare. Responding directly to the question of whether Polaris could be considered vulnerable, Brooks answered that:

> The question of the vulnerability of the Polaris system, I think, has to be, cannot be, thought of in either/or terms–that is, you cannot say absolutely either it is vulnerable or it is invulnerable. In the context in which Secretary Laird's testimony brought the thing out, the question is, is the vulnerability sufficient or is it likely at anytime in the distant future to be sufficiently great as to seriously erode the credibility of the deterrent force?

[264] Strategic and Foreign Policy Implications of ABM Systems, Anti-Submarine Warfare, Multiple Independently Targeted Reentry Vehicles (MIRV), *Hearings before the Subcommittee on International Organization and Disarmament Affairs of the Committee on Foreign Relations*, 91st Cong., 1969, 623.

> That, it seems to me, is quite a different thing from asking, is it possible that the enemy can find a Polaris submarine and destroy it? Because, it seems to me, that to erode the credibility of the deterrent requires a good deal more than the ability to find and destroy one submarine. It requires a very high assurance of being able to find and destroy a submarine on a fairly tight time schedule, and being able to do this over and over again until you essentially reduce a large part of the fleet. // I think when you put the problem in those terms, it puts the word 'vulnerability' in a slightly different perspective. In other words, it is one thing to say the system is vulnerable because in fact it is not completely invulnerable, and quite another thing to say that it is so vulnerable that in fact we can no longer rely on it for a determined retaliatory capability. I think that in your own deliberation of this problem, it is very important that this distinction be kept in mind.[265]

In response to a more pointed question about what Brooks made of Secretary Laird's statement, Brooks stated that the "only basis on which I can think of such a statement being made is just general intuition that any technological capability tends to erode after a sufficient length of time, for reasons which we cannot foresee right now, but just because we are not infinitely wise." Senator Clifford Case of New Jersey, the Ranking Republican member of the Senate Foreign Relations Committee and an early supporter of entering arms limitation talks, thanked Brooks for his answer and acknowledged his careful distinction as "the question we are concerned about, because that is the one that bears upon the soundness, or lack of soundness, of the need to preserve another element of the deterrent against destruction."[266] Case was referring to the Nixon administration's controversial plan to deploy a $20 billion ballistic missile defense system, then known as Safeguard, the latest rationale for which was the protection of the land-based force of Minuteman missiles against surprise attack.[267] Laird's dim prognosis of the survivability of the Polaris system had not been offered in a

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[265] Ibid., 626.

[266] Ibid.

[267] Stephen I. Schwartz, ed., *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons Since 1940,* (Washington, D.C.: Brookings Institution Press, 1998), 289.

vacuum. Administration officials at the time were arguing that the Safeguard system was necessary precisely because the Polaris fleet, according to their projections, could not be relied upon completely to execute a retaliatory strike, in the event of a Soviet first strike which had already decimated the Minuteman force.

Unsurprisingly, these allegations did not go undisputed for long. SPO Technical Director Admiral Levering Smith told reporters that "I am quite positive that Russian submarines cannot and are not following any of our Polaris submarines under water."[268] However, other Navy officials took a decidedly different tack in response to Laird's comments about the Polaris. Notably, the Secretary of the Navy, John H. Chaffee (a Nixon appointee) and the Chief of Naval Operations Thomas H. Moorer within weeks piled onto Laird's claims that the Polaris might soon be vulnerable to Soviet ASW. Significantly, their agreement with Laird's prognosis coincided with their announcement that the Navy would be pursuing a new submarine-missile system in preparation for the expected Soviet ASW threat.[269] As we have seen, such claims of imminent vulnerability habitually cleared the way for official justifications of follow-on developments.

At the same time that the ABM and ASW questions were being litigated, the question of whether to allow MIRV development – then well into its testing phase – to proceed or to institute a moratorium ahead of planned talks was also becoming a hot-button issue by May of 1969. One

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[268] Quoted in Strategic and Foreign Policy Implications of ABM Systems, Anti-Submarine Warfare, Multiple Independently Targeted Reentry Vehicles (MIRV), *Hearings before the Subcommittee on International Organization and Disarmament Affairs of the Committee on Foreign Relations*, 91st Cong., 1969, 636.

[269] The announcement of the Undersea Long-Range Missile System (ULMS), as the new missile was known at the time, was followed closely by discussion of a possible Sea-based Ballistic Missile Intercept System, designed to shoot down enemy missiles during their boost phase. "New, Costly Missiles Planned by Navy," *The Hartford Courant*, 2 April 1969.

Boston Globe account reported that the "point of no return on MIRV, according to the opponents, may be as soon as July."[270] Citing "bureaucrats" who insisted that there was a dynamic relationship linking MIRV to the ABM, the piece captured the urgency of MIRV opponents' claims that it was effectively now or never for lawmakers to give slated arms control talks a fighting chance of achieving meaningful controls on both offensive and defensive strategic weapons systems.

Two months to the day following Brooks' testimony, the same subcommittee of the Senate Foreign Relations Committee held a follow-up hearing on the subject of Resolutions 210 and 211, authored, respectively, by Senators Case and fellow Republican Senator Edward Brooke of Massachusetts. Each of the resolutions called on both the United States and the Soviet Union to agree to a cessation of MIRV testing on the basis that further development of this technology constituted "a fundamental and radical challenge" to the stability of nuclear deterrence.[271] By thus characterizing MIRVs, the language of the resolutions implicitly paid homage to the contention – then being advanced almost solely by arms controllers – that MIRVs represented an ideal counterforce innovation. To say that this point was still unsettled would be an understatement.

Throughout the preceding decade, MIRVs had been firmly understood, and publicly portrayed, as ABM countermeasures, designed to ensure that Soviet cities did not escape destruction behind a missile defense shield, no matter how sophisticated. In fact, MIRVs' apparent shortcomings against hardened military targets led counterforce advocates in both the Navy and the Air Force to

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[270] George Wilson, "MIRV Joins ABM as Nixon Thorn," *Boston Globe*, 24 May 1969.

[271] Strategic and Foreign Policy Implications of ABM Systems, Anti-Submarine Warfare, Multiple Independently Targeted Reentry Vehicles (MIRV), *Hearings before the Subcommittee on International Organization and Disarmament Affairs of the Committee on Foreign Relations*, 91st Cong., 1969, 646.

view them unfavorably compared to single high-yield warhead reentry vehicle designs. Why then did the prospect of MIRV development prompt such intense anxieties by the end of the 1960s, heralding a supposedly imminent and irreversible intensification of the arms race? The answer takes one full circle, back to fears surrounding the alleged vulnerability of U.S. land-based missiles to surprise attack. Indeed, perhaps surprisingly, arms controllers were among the first to publicly label MIRVs as counterforce weapons. Former Director of the Advanced Research Projects Agency (ARPA) and President of IDA Jack P. Ruina was among those called to testify at the July SCFR hearing. Himself a supporter of establishing limits on both MIRV and ABM, in his prepared statement Ruina spelled out the action-reaction logic by which many observers feared these two types of systems would accelerate U.S.-Soviet arms competition:

> In the United States, ABM deployment is justified primarily by the threat of possible Soviet MIRV deployment while our MIRV deployment is justified as a reaction to possible Soviet heavy ABM deployment. If on their part the Soviets think and react to our weapon systems as we do theirs, then we have with these two weapon systems alone the necessary ingredients for an intense and almost unlimited arms race...We in the United States view our ABM and our MIRVs to be of the stabilizing kind, but can the Soviets view our MIRVs and our ABMs the same way?[272]

Elaborating further on the anti-ABM rationales that had historically characterized MIRV efforts in the U.S., Ruina clarified that "MIRVs permit the offense the flexibility of distributing its reentering vehicles to exhaust the supply of the opponent's interceptors most effectively."[273] He went on to conclude that "MIRVs can be a very stabilizing element if it is only an ABM penetrator or a very destabilizing element if it can attack hard targets." The two-sidedness of MIRV technology's

[272] Ibid., 649.

[273] Ibid., 650-651.

potentialities recalls the sometimes-offensive, sometimes-defensive framings of both ASW and ABM capabilities. Each of these areas, as they were pursued in the United States, featured proponents who first made their case on the grounds of addressing projected vulnerabilities to Soviet countermeasures, whether those were expected to appear in the form of killer submarines, missile defenses, or MIRVs. That they ultimately produced each of these weapons systems in turn speaks more directly to the reliable operation of the measure-countermeasure dynamic of the strategic weapons R&D process than to the traditional action-reaction spiral typically charged with bedeviling the opening and ongoing process of formal arms talks.

Conclusion

The strategic debates which raged over the spring and summer of 1969 brought the problems of anti-submarine warfare, MIRVs, and missile defense all under the same national spotlight, and their juxtaposition served to highlight key features of the technopolitical inheritance that had come down through the decades of strategic weapons R&D. One of these features, and arguably the most consequential, was the practice of using the R&D process not only as an engine for driving new systems developments, but also as a technological forecast of imagined threats to come. Another of these features was the sheer mutability of any given technology's professed strategic identity. Finally, by the end of the 1960s, the chronic slippage between narrow, system-centric and broader, strategic understandings of vulnerability and survivability helped to create a discursive environment in which,

politically, administrators came to regard the statistical susceptibility of one weapon to potential countermeasures as though it presented an existential liability for the arsenal as a whole.

Conclusion

> "So well rationalized and justified was our strategic force that the way we were doing it came to be viewed as the only way to do it right. What was first only a description of the three components of the force evolved to a sanctified prescription that demanded that each element of the force should, by itself, be capable of deterring a Soviet nuclear attack under 'worst-case' conditions. The 'rule of three'–the triad–took on a sacred character quite outside the realm of the analytic decision-making process."[274]
>
> – Jack Ruina, 1972

This study has pursued two interrelated lines of investigation. The first, concerning the historical evolution of naval weapons research and development, foregrounded the work of technical communities engaged in these efforts and the ways in which they reshaped the preferences and perceptions of Navy leaders related to service plans and programs. The second, concerning the doctrinal debates and political transformations that structured and were in turn structured by these technological developments, highlighted the ways in which technical communities exercised a significant degree of agency and flexibility in imbuing weapons developments with particular strategic justifications. In tracing these threads through the first three decades of the nuclear age, this dissertation has shown that these histories are inseparable.

The processes by which technologists, planners, and politicians conferred certain strategic identities upon the weapons programs in which they maintained vested interests were also key

[274] Kosta Tsipis, Anne H. Cahn, and Bernard Taub Feld, "The Future of the Sea-Based Deterrent" (Cambridge, Mass: MIT Press, 1973), 14.

pathways through which these actors came to redefine the political landscape in which they operated. Such processes were also by no accident those most directly implicated (and most consistently overlooked) in the strategic debates that accompanied every major new technological initiative of the U.S. nuclear weapons establishment. The questions that motivated this dissertation acted to foreground those sites and interconnections through which technical communities worked to protect and improve the political fortunes facing the military R&D establishment, as it navigated the shifting terrain that characterized U.S. nuclear force planning over the two and a half decades following World War II.

In the sections that follow, I will first review the main findings of this study with regard to the three main research questions that drove this work. Following this summary, I will highlight the contributions these findings represent with respect to existing scholarly literatures on the dynamics of technological development within the military sphere, the evolution of nuclear strategy, and the character of postwar relations between the federal government, academia, and private industry. I will then turn to a discussion of the ways in which this analysis can help to illuminate certain key aspects of arms control as it has historically been conceived and practiced in the context of U.S. nuclear weapons policy since the end of the 1960s. Lastly, I will evaluate contemporary observations of the prospects facing present-day arms control in light of the insights offered by the history examined here.

The Politics of Naming

This dissertation concerns itself centrally with the political causes and consequences of what became little-historicized shifts in the strategic meanings military R&D personnel ascribed to particular weapons systems. By focusing on the evolution of anti-submarine warfare platforms and multiple warhead technology, this study has shed light on the historically contingent circumstances, challenges, and opportunities that faced the technical communities directly engaged in these developments and related avenues of R&D. Attending to these specific categories of weapons systems and the ways in which the process of their design and development played into contemporary debates about the merits of competing nuclear doctrines further revealed the formative impact of intra-Navy politics on the course of what came to be seen as a decisive shift in emphasis from assured destruction to damage-limitation as the organizing principle of U.S. nuclear force planning by the beginning of the 1970s. In the course of answering the three questions set out below, this study advances present-day understandings of how scientists, industrialists, and administrators articulated, rationalized, and continued to strengthen a sustained political demand for nuclear weapons over the first half of the Cold War.

1: What processes contributed to investing particular weapons systems with a given strategic identity?

One of the fundamental claims of this dissertation holds that one cannot account for all that went into the process of naming the strategic consequences of a given type of weapons system without investigating the history of that system's development. The particular historical conditions that

informed the individual and collective ambitions of a weapon's advocates as well as those of its critics necessarily played an important role in fashioning narratives about what that weapon ought to "do" in the context of a given strategic framework. We have seen evidence of this relationship between the political context and content of such arguments tying weapons systems to specific doctrinal positions in the history of two major technological initiatives of the postwar Navy – the drive to proliferate and diversify the suite of anti-submarine platforms and weapons systems, and the drive to develop ever more survivable generations of the ballistic missile carrying submarine.

As a mission, anti-submarine warfare during both world wars represented less of an operational specialty so much as a tactical response to the German U-boat offensive against transatlantic Allied shipping and supply lines. In the aftermath of World War II, however, scientists concerned with the task of maintaining the flow of Navy dollars to facilitate the continued growth of the young field of oceanography cultivated relationships with naval personnel eager to carve out a central place for the antisubmarine mission and undersea warfare more broadly within the Navy's overall sense of its core mission. Aiding this fledgling partnership during the earliest years of the postwar era was the acrimonious inter-service dispute over how the introduction of atomic weapons would or ought to reshuffle the roles and missions of the military branches. As Navy leaders fought a losing battle with the Air Force to retain their service's role on the frontlines of any future war, ASW partisans made an increasingly persuasive case to Navy audiences for consolidating rationales for the fleet's air, surface, and subsurface forces around the domain of undersea warfare.

Through forums such as the Committee on Undersea Warfare and the Hartwell summer study, scientists and industry representatives who stood to benefit from regularized Navy funding for

R&D capable of supporting deep-water operations characterized ASW work as indispensable both in times of peace and war, with simultaneously defensive and offensive applications. In the process, these figures developed ways of turning politically loaded charges of system vulnerability – so often deployed by critics of Navy forces during the debates over unification – into a resource as opposed to a liability. Claiming the postwar threat from Soviet submarines would be ever-present, scientists portrayed ASW as the most natural path by which the Navy could retake its former place as the first line of defense against attacks on the continental United States. At the same time, they cautioned that ASW R&D required both measure and countermeasure development to proceed in lockstep.

Placing the functionally antagonistic areas of submarine design and anti-submarine work in constant material conversation transformed the notion of vulnerability from political kryptonite into a productive site of R&D in its own right. Instead of shying away from claims of system vulnerability, scientists reconceptualized vulnerability as an inherent feature of all military platforms, weapons, and infrastructure. On this basis, these vulnerabilities were no longer simply operational shortcomings but in fact data points prompting the development of countermeasures and follow-on systems for U.S. naval forces. How this reworking of vulnerability eventually mapped onto contemporary debates regarding service strategy became clear only in light of the efforts of another group of Navy officers concerned almost solely with bringing their service more fully into the atomic age – namely, through the development of naval nuclear propulsion and subsequently the ballistic missile carrying nuclear submarine.

Most often remembered as the brainchild of the hard-driving Admiral Hyman G. Rickover, the nuclear-powered submarine was in fact the product of a conjunction of technopolitical realities

that placed the submarine, once a peripheral platform, at the center of the postwar Navy's force planning ambitions. This change of fortune, largely orchestrated by ASW proponents, presaged the sometimes uneasy alliance between the Navy's submarine designers and its anti-submarine warriors. Under the terms of the measure-countermeasure dialectic established by the architects of the postwar naval-industrial complex, the successes of the former camp immediately became the standards to beat for the latter.

With R&D leading the way in charting the extent of the technologically possible according to this logic, Navy planners increasingly turned to optimizing survivability (vulnerability's obverse) as the strategic category in which naval forces could find their niche in the developing national nuclear posture. Having been warned off the path of pursuing carrier-based platforms for its piece of the nuclear mission by its early postwar battles with the Air Force, by 1956 Navy leaders were ready and willing to move quickly on the suggestion, brought by scientists working to advance the state-of-the-art in undersea warfare, that nuclear-armed ballistic missiles could be made small enough to fit on submarines. As the first major lobby within the Navy to support the development of a submarine-launched ballistic missile, the undersea warfare community saw the Polaris program as a promising new patron for continued ASW-related R&D, repackaging many of the same techniques and instruments as supportive of the Polaris mission. While the earliest years of the Polaris development saw Special Projects Office personnel portray the program as working to produce a tactical weapon aimed at submarine pens and shipyards — in line with early postwar dispensations over targeting that Navy leaders had arrived at with the Air Force — Polaris designers successfully sought priority status for the program by claiming it served a strategic role, and was thus intended to target Soviet cities.

The mutability of the Polaris system's strategic designation proved to be a feature and not a bug, so much so that Navy personnel intimately connected with the effort to build the Polaris were themselves often unsure of their service's official line on the system's overall goal and purpose. However, this standing ambiguity posed more of a help than a hindrance to Polaris designers, who often embraced it by making key design decisions calculated to maintain what they often referred to as the operational flexibility of the weapon. With each successive generation of the Polaris missile, designers and program leaders calibrated their justifications of follow-on developments in terms that reflected and even anticipated the evolving political consensus amongst planners, administration officials, and congress regarding the ideal character of the national nuclear strategy.

It was in the course of gauging the political winds that the Polaris team elected to take the novel approach of designing the A3 missile to carry multiple warheads. At the time – in the late 1950s – the idea of placing multiple reentry vehicles on a single missile was circulating throughout the various technical communities engaged in long-term nuclear force planning as a means of countering expected Soviet ABM deployments. Informally, program officials' reasoning for incorporating multiple warhead technology into the A3 stemmed more from a fear of drawing political "censure" during future domestic political debates over ABM systems and their effects on the survivability of U.S. strategic forces. In other words, Polaris designers leveraged the technopolitical affordances of understanding multiple warhead systems as survivability enhancements in a preemptive bid to protect their program from future blowback.

As anxieties surrounding the extent of Soviet missile defenses indeed went on to dominate public debates about nuclear weapons policy, the survivability frame continued to dominate prevailing

narratives around multiple warhead technology even when reentry vehicles became "independently-targetable" – that is, well into the late 1960s. This historical trend of narrative consistency amidst technical change is significant since academics and policy professionals concerned with the history of U.S. strategic weapons development have tended to assume that it was the "I" in MIRV which made it a counterforce technology.[275]

On the contrary, as late as the early 1970s, R&D administrators continued to describe MIRVs as supportive of an "assured destruction" posture, meant to ensure that U.S. missiles would be able to penetrate Soviet defenses onto their targets, those being primarily cities. Despite these public-facing claims, the result of the designers of the Navy's ballistic missile force maintaining an in-house ethic of optimizing "operational flexibility" in each version of the Fleet Ballistic Missile was that they had attempted to design each generation to have a latent counterforce capability. However, MIRVed missiles only became branded with the counterforce label when associated with developments in Soviet strategic forces, and those who did the branding were by and large the same figures who insisted that U.S. MIRVs were comparatively benign and designed to enhance survivability. Such narratives tacitly elevated the planning assumption that a Soviet first strike would target U.S. military forces —

[275] For scholarly examples, see Ted Greenwood, *Making the MIRV: A Study of Defense Decision Making* (Cambridge, MA: Ballinger, 1975); William C. Potter, "Coping with MIRV in a MAD World," *The Journal of Conflict Resolution* 22, no. 4 (Dec 1, 1978): 599-626; Ronald L. Tammen, *MIRV and the Arms Race: An Interpretation of Defense Strategy*, (New York: Prager, 1973); For corresponding perspectives in the policy world, see Daniel Buchonnet, "MIRV: A Brief History of Minuteman and Multiple Reentry Vehicles," Lawrence Livermore National Laboratory, February 1976; Anna Schumann, "Fact Sheet: Multiple Independently-Targetable Reentry Vehicle (MIRV)," Center for Arms Control and Non-Proliferation, August 28, 2017, https://armscontrolcenter.org/multiple-independently-targetable-reentry-vehicle-mirv/.

the cornerstone of the measure-countermeasure dialectic — to the level of a foregone conclusion in the minds of nuclear weapons designers, military and civilian strategists, and defense administrators.

It is also no coincidence that the counterforce frame – which depicted MIRVs as inherently threatening to a nation's land-based missile arsenal – became widespread in national security discourses over the same span of time during which the governments of the United States and the Soviet Union embarked on the first round of arms control talks. At a time when politicians, diplomats, and the general public found themselves more squarely confronted with the question of "the nuclear balance" than at any point prior, they entered upon a discursive terrain that had for decades been shaped almost exclusively by the technical communities which had designed generation after generation of the weapons systems now being litigated at the negotiating table. One prominent feature of that terrain, the assumption that any development in the Soviet arsenal represented an attempt to neutralize some specific element of the U.S. arsenal, played a fundamental role in the emergence of narratives which constructed MIRVs as counterforce technologies.

2. Once labeled, how durably did emerging weapons systems appear to maintain such strategic characterizations throughout the various contexts in which they were proposed, attacked, defended, and ultimately judged for their political and technological viability?

The life cycles of such narratives did not lend themselves to neat demarcations, for example, between when ideas of MIRVs-as-counterforce replaced those of MIRVs-as-anti-ABM-missiles. Rather, these differing characterizations coexisted both in time and space, with defense officials casting Soviet MIRVs as counterforce systems at the same time and in the same forums that they portrayed

U.S. MIRVs as survivability measures. For example, in their testimonies before Congress in the summer preceding the start of SALT negotiations, leading scientist-administrators such as Jack Ruina and Herbert York offered exactly this sort of juxtaposition in their framing of U.S. and Soviet MIRVs.[276]

I address in greater depth the unique realities and challenges such narrative license posed (and continue to pose) for arms controllers in the final section of this conclusion. Here, I lay out the ways in which this and other forums and contexts presented sites at which technical communities changed their discursive renderings of a particular strategic weapons system. In the case of ASW, the liminal space occupied by the submarine platform through its widely regarded status as its own best countermeasure meant that, within the community of undersea warfare professionals, both defensive and offensive framings of ASW capabilities appeared prominently and simultaneously in both weapons design and force planning discussions. In other words, Navy officials and their partners in industry and academia regularly used forums technically dedicated to the discussion of anti-submarine advancements and techniques for the purpose of formulating recommendations on prospective pro-submarine developments, such as means of improving the concealment of submarines on patrol.

Interestingly, ASW itself attracted very little criticism over the decades following its postwar rise to prominence among the raft of peacetime Navy missions. While one could argue that strategic

[276] It is important also to remember that both Ruina and York each favored some form of a MIRV ban, yet their attribution of apparently clashing strategic purposes to the same technological development in the U.S. and Soviet arsenals spoke to their backgrounds as longtime members of the world of American military R&D, and pointed to some of the implications of this legacy for the world of arms control. See Strategic and Foreign Policy Implications of ABM Systems, Anti-Submarine Warfare, Multiple Independently Targeted Reentry Vehicles (MIRV), *Hearings before the Subcommittee on International Organization and Disarmament Affairs of the Committee on Foreign Relations*, 91st Cong., 1969, 646-660.

ASW – that is, the hunting of enemy ballistic missile carrying submarines – constituted a kind of counterforce mission, there are no indications to suggest that it was understood as such by any in the undersea warfare community, and indeed no evidence that it was thought of as such by arms controllers. In fact, the earliest and most powerful justification offered by scientists for maintaining large investments in ASW R&D centered around the protection of commercial maritime shipping and the defense of naval surface ships.

Furthermore, as one of the most intricate and heavily classified realms of R&D within the whole of the national military establishment, ASW escaped any easy categorization in the context of early Cold War debates about survivability. Instead, it occupied a peculiar space in the strategic imaginary that was largely obscured by claims of the ballistic missile submarines' invulnerability. Nevertheless, despite the wide-reaching faith in the survivability of the U.S. SLBM force that had been carefully cultivated by the Navy for fully a decade prior to the start of the Nixon administration, Secretary Melvin Laird's 1969 statement portending the coming vulnerability of the Polaris force quickly ignited fierce debate over the magnitude of the ASW threat to U.S. missile submarines, showcasing the fragility of any taken-for-granted feature of nuclear strategic discourses.[277]

[277] Quoted in Strategic and Foreign Policy Implications of ABM Systems, Anti-Submarine Warfare, Multiple Independently Targeted Reentry Vehicles (MIRV), *Hearings before the Subcommittee on International Organization and Disarmament Affairs of the Committee on Foreign Relations*, 91st Cong., 1969, 623.

3. How did debates about what was strategically and technologically desirable reflect and reorder the distribution of power, preferences, and perceptions among the communities engaged in long-term nuclear force planning in the United States over the course of the first half of the Cold War?

The strength of the ASW and pro-submarine lobby within the Navy emerged from a situation in which the surface and air wings of the service saw their relative influence eroded by political maneuvering from the Air Force. Additionally, the undersea warfare theater during World War II whet the appetites of scientists and technically-minded officers for a focused, long-term program of R&D. The efforts of civilian ocean scientists to professionalize the young field of oceanography led this community to proactively cultivate contacts and relationships with Navy officials and R&D administrators. These networks then leveraged the political realities facing the early postwar Navy (i.e. the threat to naval aviation, the possible obsolescence of premier naval platforms, and the complications of the Air Force monopoly on nuclear weapons) to create a sustained high-level demand for R&D related to undersea warfare.

Furthermore, these networks placed great emphasis on the utility of nuclear weapons for naval missions, putting the Navy in a stronger position to secure a greater role in the formulation of national nuclear strategy. To make Navy demand for R&D robust, scientists argued that measure and countermeasure development should proceed in lockstep, one continually informing the other. In this way, technical communities were able to reconstitute and consolidate their influential position. This measure-countermeasure dialectic helped to sustain an enduring claim among planners and top Navy officials that SSBN forces would eventually be vulnerable to Soviet ASW, even as they declared the nuclear submarine platform the ultimate in survivability. In circulating such ideas of system

vulnerability, SSBN designers and ASW partisans put in place a metric for weapons system effectiveness which took for granted the need for follow-on developments.

In the case of multiple warhead technology, the earliest MRV proponents conceived of such systems as responses to the problem of warhead vulnerability. Importantly, technical communities, particularly those responsible for building successive generations of the FBM, valued multiple warhead designs at least as much for their capacity to ensure political support for the missile developments of the 1960s as for their putative operational ability to insure future U.S. missiles against advancements in Soviet ABM technology. In fact, the developers of the A3, the first ballistic missile to incorporate a multiple warhead design, pointed both to Soviet developments and U.S. efforts in the area of ballistic missile defense in order to sell key audiences on the need for M(I)RVs.

In the process, MIRV proponents faced opposition from pro-counterforce segments of the defense establishment, due to the widespread conviction that dividing missile payloads into larger numbers of smaller, lower-yield warheads would make the task of destroying hardened military targets much more challenging. Thus, the earliest MIRV advocates, most notably those involved in the FBM program, evolved ways of circumventing pressure to adopt large, single-warhead designs favored by counterforce partisans. In doing so, they helped accelerate efforts to increase the accuracy of next-generation guidance and navigation systems, while working to reconfigure the set of technical and operational criteria deemed acceptable–and eventually ideal–for a counterforce weapon. In other words, MIRV proponents made the case that going to larger numbers of smaller warheads could in fact prove just as effective for striking hard targets if not superior to one high-yield warhead, in light of the greater accuracy figures they claimed could be expected from future missiles.

To be sure, defusing and deflecting pressures to adhere to yield-centric definitions of counterforce design also depended on a confluence of contingent realities which lent support to MIRV advocates in their attempts to craft more accuracy-centric understandings of what qualified as a counterforce weapon. Chief among these realities was the Kennedy-Johnson administration's emphasis on the importance of survivability and flexibility as primary metrics for assessing the desirability of proposed weapons systems. As these priorities also formed the leading rationales deployed by MIRV advocates, civilian planners such as those in the office of the DDR&E developed early on a favorable impression of the technopolitical affordances offered by prevailing characterizations of multiple warhead technology as the ultimate "anti-antiballistic missile." Such narratives positioned MIRVs not only as effective operational responses to the anticipated deployment of a Soviet ABM system, but moreover as an effective political weapon in the fight to manage the vast ambitions of the military services with respect to future procurements.

The technopolitical affordances of multiple warhead systems thus included a means of defusing politically sensitive perceptions of the vulnerability of U.S. strategic forces as well as a means of discrediting the arguments of those in favor of the United States pursuing its own ABM program and a numerical buildup of its land-based ICBM arsenal. Indeed, so useful were MIRVs in their notional form as anti-ABM talking points that they encountered their strongest opposition from staunchly pro-counterforce segments of Navy and Air Force leadership, while opposition from arms controllers was by comparison slow to develop.

As noted by Greenwood in his seminal study, MIRVs provided solutions to a variety of different problems for a number of distinct audiences.[278] This dissertation further makes the case that in order for MIRVs to have served such multifarious ends, both politically and operationally, leaders of the Fleet Ballistic Missile program had to consciously construct and maintain its high degree of interpretive flexibility. Over the course of a decade prior to public MIRV debates, FBM designers proactively cultivated their program's reputation for survivability, while simultaneously adapting to the emergence of greater pro-counterforce sentiments within the Navy as well as within the broader military establishment. FBM designers' efforts to make MIRVs "work" for counterforce operations at a time when planning assumptions ran directly counter to the use of multiple warheads against military targets demonstrated the malleability of the strategic associations that designers could apply to a given weapons system.

Contributions

This study has contributed to present-day understandings of how technical communities engaged in military R&D participated in, navigated, and shaped the nuclear strategic debates of the first half of the Cold War. In so doing, this dissertation offers a critical analysis and perspective for scholarship across multiple disciplines, including those of security studies, nuclear history, STS, and the history of science and technology. In this section, I will lay out the insights that can be gleaned

[278] Greenwood, *Making the MIRV,* 138.

from this work and the ways in which they might serve to resituate existing studies as well as to illuminate paths for future research.

Security Studies & Nuclear History

Within the field of security studies, few other subjects have garnered as much scholarly attention as the study of nuclear weapons — of their technological development and of the intellectual frameworks devised to understand their impact on world politics. Unlike many of these past studies, however, this dissertation has proceeded from the premise that any historical analysis of these subjects must simultaneously treat these weapons both as technological artifacts and as discursive objects subject to evolving (and unstable) political renderings. This starting point brings into sharper focus the full range of actors engaged in the process of "decision-making" on matters of long-term nuclear force planning. Specifically, this study has homed in on the technical communities responsible for designing and building the earliest generations of naval nuclear weapons delivery systems as well as a range of countermeasures thereto. Indeed, those engaged in Navy-sponsored R&D in the areas of solid-fuel development, warhead miniaturization, guidance and navigation systems, nuclear propulsion, and anti-submarine warfare – in addition to being generally under-historicized compared to contemporary Air Force developments – played an under-examined role in laying the groundwork for the discursive shift in U.S. nuclear strategic policy by the early 1970s to an explicitly counterforce, "war-fighting" nuclear posture.

In paying attention to this particular professional community and its engagements with the various political currents emanating from the broader national military establishment and beyond, this

study has yielded a number of relevant insights for scholars of security studies and nuclear history. First and foremost, this work demonstrates that a bureaucratic politics lens can often obscure more than it reveals. The professional networks, political struggles, and controversial settlements that were largely contained within the Navy itself exercised a great deal of influence not only on naval R&D policy, but on the ultimate shape and direction of naval force structure. Inter-service disputes, while real and significant, could not fully explain the central place that the ASW mission came to occupy within the postwar Navy, nor the role that ASW advocates played in the development of the ballistic missile submarine, without taking into account the intra-organizational dispensations which prefigured, complicated, and placed boundary conditions on the more visible decisions of Navy leaders.

Secondly, this dissertation has helped to contextualize the story of MIRV development within a longer genealogy of military R&D and the facilitating logics produced therein. While existing case studies of MIRV development mention the Polaris A3 as an early progenitor of the MIRV concept, these treatments nonetheless dismiss the origins of the A3 itself as a source of historical context for the ways in which later MIRVs came to be understood politically. By contrast, this study not only takes seriously the place of the A3 in the evolution of multiple warhead technology, but further argues that the rationales deployed in service of its development soon became the standard justification for future MIRV systems for the duration of the 1960s. Understanding the benchmarking function that ASW came to play for Navy designers in assessing the survivability of the Polaris missile offers a concrete example of the horizontal linkages between lines of R&D typically regarded as separate, and thus treated separately in the academic literature. Such connections moreover cast a different light on contemporary debates over the survivability of U.S. nuclear forces, given the fact that the shape that

those feared vulnerabilities took came almost exclusively from knowledge of the types of countermeasures then being designed and developed within the U.S. nuclear establishment.

This point leads to the third key takeaway that this study can offer to the field of security studies. Allowing the temporal and spatial bounds of this study to vary according to the relationships it uncovered among various actors, expanding or contracting the scope of the analysis to permit deeper and fuller explanations of the origins and functions of these relationships, fundamentally reshaped the object of analysis and the kinds of conclusions it became possible to draw. This orientation of openness to discovering the point at which one enters the description of the problem one is after can prompt a generative reevaluation of one's own priors and the ways in which these can systematically eclipse important bodies of historical evidence or render them in a distorted, one-dimensional light. For example, and as a preview of the final section's discussion, had this dissertation not asked what historical conditions first gave rise (and then gave credibility) to commonly held narratives which continue to surround the weapons systems that the SALT process is often blamed for failing to control, it would not have been possible to uncover the extent to which those narratives had already been crafted – alongside the systems they purport to describe – with the express purpose of insulating these technologies from political opposition or the encroachment of regulatory mechanisms.

In security studies, many of the field's foundational terms have served as potent instrumentalities in the parlance of national and international security discourse. Thus, ahistorical treatments that ignore or falsely presume a shared understanding with the way these key terms have circulated amongst political actors risk reifying highly contingent, shifting definitions into misleadingly static categories, oftentimes with the result that the political dimensions of specialized

language and the communities which produce it get collapsed and go unrecognized. It is one hope of this work that future security studies scholarship will take on the same reflexive shift in the definition of their research questions, turning the former terms of analysis into the objects of historical examination.

STS & Histories of Science and Technology

The reflexive shift that resulted in this dissertation came in large part out of a prolonged engagement with the work of STS scholars and historians of science and technology. As a self-described "interdiscipline," STS in particular helped to expand the array of analytical tools available for conducting a historical study of early nuclear weapons R&D. In turn, this dissertation stands to provide what is hopefully a compelling invitation for future STS research on the history of the national security state and its continuing investments in science and technology. At present, topics long considered the purview of security studies and international relations, such as nuclear weapons and arms control, have generated relatively little interest among STS researchers (though, to be sure, there are exceptions).

One obvious site of STS inquiry that would stand to benefit from a critical analysis of such issues can be seen in this dissertation's engagement with the politics of naming in processes of technological development. The demonstrable stakes of assigning particular strategic identities to particular technologies or weapons systems point to the central importance of naming in the ways technologists, state-sponsored and otherwise, build alliances and consolidate political power in support of their technopolitical agendas. Indeed, the concept of technopolitics itself provides a readily

applicable analytical tool for examining the material and discursive inheritance of technological developments nominally undertaken under the banner of national or international security.

In addition, some STS scholars might understand this dissertation to be a co-productionist account of nuclear weapons development and the formulation of the strategic concepts meant to guide the organization and employment of nuclear arsenals.[279] While this reading would be consistent with the evidence adduced here, further research would be necessary before such a claim could be adequately substantiated. Whereas co-production denotes a process whereby scientific ideas and technological objects evolve alongside the discursive, institutional, and social frames that contain them, this study does not conclusively establish whether the nuclear strategic terms of interest were themselves inventions of the R&D process that produced the weapons systems examined here.

Rather, this study finds that certain usages and understandings of these terms circulated and evolved in ways that tracked in line with the political goals defined by technical communities and their allies in charge of associated programs of R&D. In order for a strong case to be made for a co-productionist interpretation of this study, one would need further to establish whether the lexicon of nuclear strategic jargon had its origins in the same processes of technopolitical maneuvering described here, prior to being systematized by the familiar theorists most often credited with their elucidation. Nevertheless, this work offers a useful starting point for STS scholars interested in exploring further

[279] Sheila Jasanoff describes co-production as an "idiom" for describing the means by which "ways of knowing the world are inseparably linked to the ways in which people seek to organize and control it." For an instructive collection of co-productionist scholarship, see Sheila Jasanoff, *States of Knowledge: The Co-Production of Science and Social Order,* (Abingdon, Oxon: Routledge, 2004).

the ways in which the historical associations between military technology and military strategy are politically mediated.

Arms Control Underwater

Throughout most of this dissertation, arms control has remained a largely spectral presence. Despite the role of its recent reversals and widely perceived historical shortcomings in motivating this study, arms control has since receded less to the background so much as to the margins of the historical account provided here. This shift came about gradually and in response to unanticipated, counterintuitive encounters with the asymmetry of political context present in discussions of weapons systems that took place amongst arms controllers versus those had amongst weapons designers. That is to say, where the former tended to proceed along well-worn lines prescribed by ostensibly timeless strategic dictums, the latter often betrayed the instability of these categories, in ways which served to pinpoint the origins of a specific political threat, objective, or reality pertinent to the survival of their given program.

By this, of course, I do not mean to imply that the deliberations of arms controllers were devoid of political content. Instead, I observed that the ways in which arms controllers described the arms they were attempting to control by and large took for granted the public statements of civilian and military officials responsible for overseeing the development of these same weapons. By contrast, those most directly connected to the R&D process took far more instrumental approaches to describing their technological creations. As a result, technical communities quickly came to the fore as the prime movers animating this account. Nevertheless, while any comprehensive historical treatment

of the means by which particular kinds of nuclear weapons came to have particular strategic meanings must necessarily undertake a close examination of the history of the arms control process, there remain some crucial insights that can be taken from this study of the U.S. Navy's own under-examined role in these complex histories.

Perhaps most importantly, the significance of what I have called the measure-countermeasure dialectic seems difficult to overstate. As claims of approaching periods of system vulnerability became bound up with the in-house state-of-the-art in strategic weapons R&D, the demands of weapons designers for follow-on systems that appeared like clockwork amidst the frenzied pace of invention could look, from some angles, like an inevitability. However, this illusion of momentum derives principally from the historically opaque structural features of the R&D process, by which a feedback loop connected the work of specialists in the functionally antagonistic mission areas of anti-submarine warfare and the strategic nuclear mission carried out by submarines. The primary implication of this dynamic for arms control can be seen in the way that both arms control itself and the R&D process evolved to cement a condition of vulnerability, albeit with the disturbing result that the kind of mutual vulnerability arms controllers believed would maintain the nuclear balance and ameliorate the arms race could in fact only beget ever more costly rounds of modernization.

Acknowledgements

This dissertation would not exist without the support and care of a community, and it has been my good fortune to receive both in spades from friends, colleagues, and family alike. I hope that, over the years, I have made clear to each and every member of my community the depth of my gratitude. The following is a humble summary of the kindnesses, too numerous to list, that I have been paid in the course of this work.

First, it is no exaggeration to say that I could not have pursued the questions I have taken up here were it not for the trust and patience freely given to me by my advisor, Chris Chyba. Both as a scientist and as a public servant, his commitment to life — never abstract, no matter the scale (nor the planet!) — has been an inexhaustible source of encouragement and reasons for optimism throughout my time at Princeton. I could not have been better guided through the tumult of these six years than I have been as his student.

Michael Gordin, the second member to join my committee, steadily whittled away at my use of the passive voice until human beings at last sprang forth from the account I present here. Whatever degree of human agency I have managed to uncover in this work is in large part a product of his generous engagement. Our conversations never failed to clarify for me the lessons that accompanied both the highs and lows of the research process. And while the road to completing this dissertation was indeed far from straight, it was a far smoother journey for his joining me along the way.

Sharon Weiner, the third member of my committee, was instrumental in shepherding this project through the many twists and turns of my cross-disciplinary investigations. Her incisive feedback on everything I produced, whether I had written my thoughts down clearly or grasped at them vaguely over the phone, always left me feeling more confident and energized to stay the course.

Ruha Benjamin, though she was the fourth and final member of my committee, was the first scholar to introduce me to the world of science and technology studies. I took my first tentative steps toward this community drawn by her example, without which I could not have grasped the social and political possibilities latent within our work as scholars. Her kindness, generosity, and dedication to the task of liberatory analysis placed the work of completing this project in a perspective that I needed to move forward at many challenging junctures.

As luck would have it, I had the benefit of learning not only from the brilliant members of my committee, but from the many others without whom I could not have learned, laughed, or grown as much as I did throughout my time in graduate school. Abdi Dirie and Jahnavi Kalpathy, some of my oldest and dearest friends, have supported me so consistently over the years that I've marveled at their patience and good humor since we were teenagers.

Lina Abushouk – "Father of Thorns," walking, talking multi-verse, and an overall credit to her name – expanded several-fold my imagination of what it was possible to become simply by keeping a heart as open as one's mind. She and Tara Suri, another brilliant soul on whose friendship I've come to depend, despite the vast (physical) distances that have always separated us, became life rafts to me as I waded through the murkiest parts of the writing process. Sarah and Andrew Chelius, RL Goldberg, and Kalie Pierce, each among the kindest, most singular human beings I've ever met, have taught me more than I could ever commit to paper about what matters in this life and in the work we devote it to.

In addition, if recent years have taught us anything, it was just how meaningful is the work of health care professionals of all kinds. During my time at Princeton, I was lucky to have the generous care and support of Dr. Valerie Lewis and University Health Services. And of course, Dr. Carol Valentin, for whom I'll always be grateful, gave me the tools to care for and speak my mind in even the most challenging environments.

Finally, this journey itself would not have been possible without my family, to whom I owe everything. My mother, Aster Baheru, the proud granddaughter of Bizunesh Robi, spent many sleepless nights keeping my spirits alive with her loving company, helping me push past obstacle after obstacle. Her father, my grandfather, Baheru Faye, gave the world an immeasurable gift when he raised her in full view of the strength and grace of her foremothers. My own father, Mulugeta Betre, left me more than a lifetime's share of enthusiasm and curiosity about the world, which he embodied. My sisters, Nebeyatt and Rahwa, are the best parts of him, and I couldn't be more grateful for their example.

Regrettably, I've done far short of a comprehensive job in thanking everyone who deserves all the flowers I have to give. Still, I hope that, in all that I do, I make clear to those around me how necessary they have been and how necessary they still are. The work is far from finished, but I take heart in knowing that the work is shared.