Prelude to *Dreadnought*:
Battleship Development in the Royal Navy, 1889-1905

Dissertation

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By

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Abstract

The Royal Navy went through an important period of growth and development between 1889, with the passage of the Naval Defense Act, and 1905, when construction on the Dreadnought commenced. Though the pre-Dreadnought era of ship design and construction is often seen as a period characterized by resistance to change and self-satisfied indifference to the value of new technology for naval warfare, it was instead a period of cautious, measured and successful adaptation of new technology, which produced powerful and effective battleships. The Royal Navy was able to do this because it had developed a systemic method for designing ships and incorporating new technology into those designs. The system was able to effectively decide on the role the battleship would fill within the broader context of naval operations. It decided how to balance the competing demands of the capabilities that were wanted to fill that role in an environment of strict limits on space, weight and money available. The system also evaluated new technology and determined what filled the Navy’s needs and produced better ships. The period between the Naval Defense Act in 1889 and the Dreadnought in 1905 is a vastly underappreciated period in the history of the Royal Navy. It was not a period of failure for the Royal Navy, as least so far as ship design and technological advancement were concerned, that can be dismissed as something that “Jackie” Fisher needed to fix. The Royal Navy had its failures at that time, to be sure. However, the failure effectively design its ships and to grapple
with new technology and adapt and adopt it for its ships, most importantly, its battleships, was not one of them.
Dedication

This is dedicated to my ever-patient wife, Janine
Acknowledgments

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Introduction

Introduction

The history of the Royal Navy of the United Kingdom of Great Britain and Ireland during the decades before World War I is often implicitly broken into two parts. The first part consists of the two or three decades before 1905, during which the Royal Navy stagnated. The personnel, particularly the officers, basked in past glories of the age of “wooden ships and iron men.” The senior leadership hated “dirty” machinery, was dedicated to spit and polish as an end and not a means, and was given to reminiscing about the days of their youth under sail. At best, they moved only slowly to modernize, and at worst, they obstructed the adoption of new technology for their warships. While the Royal Navy remained the world’s premier military force at sea, it did so only because of its enormous head start; it did little to continue to earn the honor.

The second part of this story consists of the decade after 1905, when Admiral John “Jacky” Fisher was appointed First Sea Lord and began dragging the Royal Navy kicking and screaming into the 20th century with a series of reforms. The most prominent of these was the construction of the H.M.S. Dreadnought, the first all big gun battleship, which was adopted as the new pattern for all future battleships. Fisher forced the Navy out of its complacency, and to embrace new technology and its consequences for naval warfare. Under Fisher, the Navy reformed itself into a force capable of fighting and
winning a naval war against a determined opponent. The two periods are sharply juxtaposed as consisting of drift and activity, of self-satisfied decline and renewed vigor.\(^1\)

There is some truth in this slight oversimplification. It is accurate in that, to a certain extent, the Royal Navy before Fisher’s term as First Sea Lord was bogged down and lacked energy and direction. It was particularly weak in its thinking, planning, and education, and it used its resources inefficiently.\(^2\) For example, it had only just begun to restructure officer training and adapt to the changes caused by the shifts in economic and military power of the late 19\(^{th}\) century.\(^3\) Overall, it was a self-satisfied and somewhat

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lethargic organization. Fisher injected energy and direction into the Royal Navy. He accelerated the reorganization of the fleet, and changed policies and procedures that had been pursued solely out of institutional inertia. He streamlined the decision-making process and did push the Navy into adopting new technology much more quickly. Fisher also brought conflict and division with his arrogance and disregard for others’ opinions, but he did make drastic and essential improvements to the Royal Navy.

However, the idea that Fisher upended an organization that built new ships with little regard for technological changes and avoided new technology on principle is incorrect, as is the notion that there was no real system and little direction in the decision-making process that produced the Royal Navy’s ships until Fisher intervened. This study corrects both of those perceptions, and shows the leadership of the Navy in a much more positive way. The Royal Navy’s leaders were far from being reactionary technophobes, but were instead cautious professionals who understood the value of new technology but also understood its potential limits. The leadership of the Navy demanded, at times very strongly, that the efficacy of new technology be proven before it was introduced into Naval vessels. The Navy weighed potential advantages carefully against the need to have dependable, reliable weapons systems. Its leaders had enormous responsibilities—the security of Great Britain and the Empire—and were not about to take chances on their ability defend it.

Similarly, the Navy had a system in place to develop battleships and their related sub-systems that worked well. This system revolved around the Board of Admiralty and

included other senior officers with experience and technical expertise. It harnessed the collective knowledge and wisdom of these officers to decide what was needed, what could be made to work, and what could be integrated both with existing systems and with other new systems being developed. The system resulted in a steady flow of high quality, technologically advanced, and steadily improving ships, which allowed Britain to maintain its ability to meet its most important security goals.

*The Battleships and their Chroniclers*

This process can be seen clearly in the development of the Royal Navy’s battleships. In 1889 the Royal Navy began, with the Naval Defense Act, what ended up being a decades-long naval buildup. From 1889 until 1905, when the *Dreadnought* was begun, the Royal Navy developed eight classes of battleship, commissioning 42 new ships by the end of 1905.4 A number of high quality works provide technical information on these ships. Oscar Parkes’ work, *British Battleships, A History of Design, Construction and Armament, 1860-1950*, is the standard reference for all iron and steel constructed (and the limited number of wooden, ironclad) British warships that would have been in the “line of battle,” along with their close relatives, the battlecruisers. For each ship, Parkes provides information on size, armament, protection, engineering plant, fuel capacity, construction time and costs, the constructing firm or Navy dockyard that built it, a sketch plan or photograph (often both) of every different design, and a brief service history. He

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4 Five additional ships were under construction, the last of which were completed in 1908. In addition, the Royal Navy built three small, second-class ships and purchased two others.
includes short essays on related topics, such as trends in shipbuilding and important
individuals and controversies, and also interweaves editorial comment into every part of
the work. Parkes spent thirty years researching and writing the work, and though he had
only limited access to official documents, it is an indispensable reference.\(^5\) R. A. Burt’s
*British Battleships, 1889-1904* is a similar reference that includes diagrams of machinery
and a more detailed record of the service lives of the ships.\(^6\) *Conway’s All the World’s
Fighting Ships, 1860-1905*, provides a brief overview of all British battleships, as well as
all other classes of British warships and warships of every other Navy in the world for
comparison.\(^7\)

David K. Brown’s *Warrior to Dreadnought, Warship Development, 1860-1905*,
the most important examination of British warships of the time, fills out the information
provided in the reference works. *Warrior to Dreadnought* is a detailed examination of
the technical issues involved in ships and shipbuilding. Brown retired as the Deputy
Chief Naval Architect of the Royal Corps of Naval Constructors in 1988, and he has an
appreciation and understanding of difficulties of the design and construction of warships.
Brown’s explanations of the growth of practical and scientific understanding of structural

\(^5\) Oscar Parkes, *British Battleships, A History of Design, Construction and Armament,
219, for Parkes’ access to official records.\(^\)


\(^7\) Roger Chesneaux and Eugene Kolesnick, eds., *Conway’s All the Worlds Fighting Ships,
1860-1905* (London: Conway Maritime Press, 1979), see especially pp. 3-40 for British
battleships, monitors (small, heavily armed, coast defense ships) and sailing ships of the
line in service as of 1860.
issues, buoyancy, stability, and steam engineering are essential knowledge for understanding the problems facing designers and builders of warships. He also addresses issues of weight and cost that were major concerns.  

Other works provide a broader overview of the development of naval technology in the late 19th and early 20th centuries. William Hovgaard’s *Modern History of Warships*, originally published in 1920, provides an overview of the developments of warship technology. Hovgaard, a former Danish naval officer and a Professor of Naval Design and Construction at MIT, wrote a basic primer “for the use of students of naval construction, naval constructors, naval officers and others interested in naval matters,” and included material on the evolution of technology from the early ironclads through “recent war experiences.” A newer and somewhat less technical work, *Steam, Steel and Shellfire*, edited by Robert Gardiner, includes a dozen essays by naval historians and covers the entire period between the introduction of steam engines and the *Dreadnought*. It is well illustrated and a bit more accessible without sacrificing technical details. Both of these works place developments in Britain in the broader context of changes in naval technology worldwide.  

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8 Brown, *Warrior to Dreadnought*.  
Impatient Officers, the Image of the Pre-Fisher and Fisher Era Navy, and New Interpretations

If the pre-Fisher Navy was not a reactionary and ineffective organization, why did that perception emerge? Part of the answer lies in the points outlined above: the Royal Navy and its leadership had significant flaws. There is, however, much more to it. While the Royal Navy cautiously changed its technology and methods, it did so slowly and deliberately. The pace of change was not always satisfactory to all officers, most notably Fisher. These officers, and their characterization of “caution” as “obstinacy,” dominated the discussion of the Navy after World War I, and their opinions have shaped popular and scholarly opinion since. This is similar to the idea of the winners write the history, but not quite. It is more like, those who record their ideas and points of view write the history.

These impatient officers were able to shape the narrative for a variety of reasons. To begin with, the environment was well suited for criticism of the Navy to thrive. The sometimes disappointing performance of the Navy during the war, particularly the failure to win an unrealistically expected “second Trafalgar” to destroy the German High Seas Fleet, along with problems with submarines, meant that many within and outside of the Navy were prepared to believe that it had failed to overcome significant problems. The outspoken Jacky Fisher, the leading critic of the Navy’s organizational conservatism, dominated the discussion of the Navy in the decade before the war and remained integral to it until his death in 1920.10 Fisher more or less set the terms of the discussion, which

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were primarily that he and a small cadre of officers had to engage the forces of reaction to make vital changes to the Navy. Within an environment of disappointment with its performance, any kind of criticism of the Navy was more likely to be accepted.

In addition, legitimate criticisms of the pre-War Navy granted extra credibility to the critics, which translated into acceptance of critiques that were less accurate. Thus, when Fisher or others criticized the lack of creative thought among senior officers before the war—a legitimate criticism—further criticism that senior officers were also reactionaries opposed to new technology was more likely to have been uncritically accepted, as well. The critics’ credibility was further enhanced because many had been strong early advocates of changes in technology that the Navy adopted only slowly. This made it look like senior officers who were not Fisher allies were against good and necessary changes. What was lost in the discussion at that time, and usually continued to be lost later, was the critics’ benefit of hindsight. For every new technology that worked, there were probably a dozen that did not. However, decision makers at the time did not have the benefit of being able to look back: they had only limited information. Caution with unproven technology perhaps delayed the introduction of certain good new technologies, but it also prevented the waste of resources and the potential for catastrophic failures by preventing the introduction of technology that was ultimately

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demonstrated not to work well or at all. Fisher conveniently forgot that many of his ideas that were ultimately impractical dead ends.\footnote{Two wartime examples show the pattern here: the coal powered, steam driven “K” class submarines, meant to operate with the battle fleet, and the \textit{Courageous} class “large light cruisers,” which were underarmed and underprotected, but fast, small battlecruisers, which were later converted to aircraft carriers.} This important point was lost.

Superficial issues also played a role in making the pre-Fisher Navy look technophobic. For example, the slowness to give up boarding drills (and their weapons), which was not done until 1905, makes the senior officers of the Navy look bad, but is an indication more of institutional inertia than technophobia. The enthusiasm of Admirals for sails as late as the close of the 19th century also looks bad superficially, as does the fact that the Navy was still bringing small cruisers rigged for sailing into service as late as the turn of the century. However, two facts indicate that unthinking objection to steam technology was not the cause, or at least not the whole cause. First, advocates of sails and sail training emphasized their “character building” role, and while they may have looked back fondly on the days of sail, they were not arguing for a return to it.\footnote{See Reginald Bacon, \textit{A Naval Scrapbook, the First Part, 1877-1900} (London: Hutchinson and Company, 1925), p. 33; Gordon, p. 165} Second, the transition from sail to steam was not a clean, abrupt transition. As late as the 1870s, steam engines were so fuel \textit{inefficient} and unreliable that sails were still important for propulsion. In addition, ships serving on distant stations or cruising far from coaling stations still required sails, probably until the mid-1880s, when new, more efficient engines types became available. As late as 1882, and probably later, the majority of merchant shipping—at least British merchant shipping—in the Pacific used sails for
propulsion.\textsuperscript{13} By 1900 sail power was obsolete but it had not been so for that long. However, “clinging” to sails could be painted as a refusal to embrace new technology and evidence that many of the leadership of the Royal Navy were obstructionist technophobes. Thus, proponents of this view had both fertile argumentative ground and some measure of credibility with which to propagate their views.

Once established, this image was cemented into history by the written accounts of the period. The advocates of aggressive change were the ones to publish after the War. A brief sampling includes Fisher’s two volume memoir, \textit{Memories and Records}, which was less a memoir and more a collection of speeches and writings, published in 1920. Admiral Percy Scott, another impatient reformer, published \textit{Fifty Years in the Royal Navy} in 1919, which was highly critical of the Navy’s slowness to adapt new ideas for equipment, especially his new ideas. Admiral John Jellicoe, a Fisher protégé, published his accounts of the naval war, with books in 1919, 1921, and a third in 1934.\textsuperscript{14} Admiral K. G. B. Dewar, a lieutenant during the war, published \textit{The Navy from Within} in 1939. Admiral Reginald Bacon, another Fisher protégé, published the first part of his memoirs, \textit{A Naval Scrapbook, the First Part, 1877-1900} in 1925, and the second, \textit{From 1900 Onward}, in 1940. Bacon also published \textit{The Life of Lord Fisher of Kilverstone}, a two volume biography of Fisher and \textit{The Life of John Rushworth, Lord Jellicoe}, in 1936. Thus, aggressive reformers were able to dominate the literature and control the

\textsuperscript{13} David K. Brown, \textit{Warrior to Dreadnought}, p. 106.

\textsuperscript{14} Two of these books were on the submarine war but still, obviously, present Jellicoe’s point of view on naval issues before and during the war.
interpretation of the history of the period. They exemplify the statement attributed to Winston Churchill that “History will be kind to me because I intend to write it.”15

Finally, the pioneer historian of the Royal Navy between 1880 and 1920, Arthur Marder, cemented the negative view of the bulk of Royal Naval leadership. Marder began his studies of the Royal Navy in the 1930s and published his first book, *British Naval Policy 1880-1905, The Anatomy of British Sea Power*, in 1940. He followed with three volumes of the correspondence of Jacky Fisher, *Fear God and Dread Nought: the Correspondence of Admiral of the Fleet Lord Fisher of Kilverstone*, in the 1950s, the five-volume *From the Dreadnought to Scapa Flow: the Royal Navy in the Fisher Era, 1905-1919* during the 1960s, and further works in the 1970s. Marder’s scholarship became the bedrock of the study of the Royal Navy from the late 19th century through World War II. Marder lionized Fisher, and his work reinforced the interpretation that the

Royal Navy was locked in the grip of reactionaries and only a small number of officers, led by Fisher, saved it.\textsuperscript{16}

Most historians have followed the narrative established by postwar critics of the pre-Fisher Royal Navy, led by Fisher and Marder.\textsuperscript{17} However, there are problems with accepting these conclusions without further corroboration. Fisher and other reforming officers were not disinterested observers, and had their own positions to justify reputations to protect from post war recriminations. Their assertions should not be accepted uncritically.

In addition, the work of Arthur Marder has come under challenge in several areas. Ruddock Mackay, a Fisher biographer, authored an article in the journal \textit{Mariner’s Mirror} that countered Marder’s assertion that the fleet redistribution undertaken by Fisher in 1904-05 was a reaction to the growing threat of the German Navy, and instead argued that it was more a reaction to rising French and Russian naval power.\textsuperscript{18}


\textsuperscript{17} Some examples: Richard Hough, \textit{The Great War at Sea} (Edinburgh: Birlinn Limited, 1983); Peter Padfield, \textit{The Anglo-German Naval Rivalry, 1900-1914} (London: Hart-Davis MacGibbon, 1974); N. A. M. Rodger, \textit{The Admiralty} (Lavanham: Terence Dalton LTD, 1979); Gordon, \textit{The Rules of the Game}.

Sumida’s *In Defense of Naval Supremacy* asserts that Fisher was appointed First Sea Lord not to counter the German threat but because he was prepared to cut the Naval budget. Further, Sumida contends that the dreadnought battleship was but a stepping-stone to the battlecruiser, Fisher’s real goal and part of the cost cutting plan. Finally, Nicholas Lambert asserts in *Sir John Fisher’s Naval Revolution* that Fisher wanted to eliminate the battleship and the trade protection cruiser and replace them with battlecruisers and torpedo-armed small, cheap, ships (destroyers and submarines—squadrons of which were referred to as flotillas). This was part of a radical rethinking of naval strategy, as torpedo armed flotillas would become the primary arm defending the home islands. Fisher thought this possible because of the vulnerability of large ships in coastal and “narrow” waters and, more importantly, the vulnerability of transports to torpedo attack. Battlecruisers would both run down enemy commerce raiders, to which they would be superior in speed and armament, and supplement the flotillas.19

While much of this reinterpretation is beyond the scope of this work, which is focused on the period before Fisher and the dreadnought revolution, it does show that Marder’s work is not beyond criticism. In addition, there is another, major problem with Marder’s credibility. It has emerged that Marder did not have the privileged access to the Royal Navy’s archives he claimed. Instead, recently released files show he had unauthorized access to very limited material, and his contacts inside the Admiralty were

investigated for security breaches. Marder’s claim to understand Fisher’s goals and motives, as well as his assertion that Fisher was appointed to counter the German threat, would seem to be the most damaged of his conclusions, as they would have been most dependent on his claim to special access. While much of Marder’s narrative is reasonably congruent with other sources and survives intact, all of his major conclusions are open to serious doubt.

*Battleship Development and Technological Adaptation, 1889-1905*

The efforts to update the history of the Royal Navy in the late 19th and early 20th century, led by Jon Sumida and Nicholas Lambert, have focused on the reinterpretation of the Fisher/Dreadnought era. Little has been published, however, on the first part of the conventional story, focused on the preceding years going back to the Naval Defense Act of 1889, which marked the beginning of the build up of the Royal Navy before World War I. Given the successful critiques of the history of the pre-World War I Royal Navy and the reliability issues of Marder and the officers who created the traditional view of the pre-Fisher Navy, a new examination of the process of decision making and the technological development of the late 19th and early 20th century Royal Navy is in order. This study examines the design and development of the Royal Navy’s battleships between 1889 and 1905. It shows that the Royal Navy had evolved a systematic approach to designing its battleships and incorporating new technology into its designs.

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20 Jon Sumida, private conversation, May 8, 2009. Dr. Sumida is currently investigating the full details and implications of these files.
At the center of this system was the Board of Admiralty, the executive body of the Navy. It had both the formal authority and respect within the institution to make decisions about ships and technology. Other senior officers, including admirals in command of fleets, ship captains, and technical experts—usually heads of departments concerned with ships’ equipment—supplemented the Board. While they did not participate in the Board’s formal authority, they were important players in the decision making process. This system created a “college” of decision makers, virtually all of whom were naval officers, and was an effective means of harvesting the collected knowledge, experience, and wisdom of the fleet’s long-serving officer corps. This college also made use of other technical experts, both uniformed and civilian, as consultants for questions requiring more specialized expertise. Using this system, the Royal Navy produced a steady flow of high quality, technologically advanced ships, which improved steadily over time as new technology was introduced.

The system was not generally sensitive to the idiosyncrasies of particular individuals who assumed roles within it. This was partially a reflection of the collective nature of the system—an individual was no more than part of the process, surrounded by others. In part, it reflected the common background, training, and experience of the various men in it. However, this is not to say that the individuals could not exert their influence, and Fisher, for example, was an important figure in the administration of the Royal Navy long before he became First Sea Lord. Yet the pivotal individual between 1889 and 1905 was Sir William White, Director of Naval Construction, who was the civilian chief designer of ships and overseer of all ship construction for the Navy. White
was a highly unusual, indeed unique, member of the college in that he was not a naval officer or First Lord of the Admiralty. However, his expertise and deft ability to manage the naval officers diplomatically throughout the process meant that he emerged as the most influential and important person in the ship development system.

In making decisions about its ships, the Royal Navy was operating in an environment of limits. Some limits are externally imposed and are part of the physical environment. The laws of physics regarding mass, motion, heat, friction, and so forth are the primary physical limits; closely related are the limits of knowledge and ability to manipulate materials to achieve desired results. These limits are absolute, even if only temporarily so in the case of knowledge limits. Other limits, however, are human-imposed, such as limits on size and cost. These could be imposed by outside forces, such as budget limits from the Government and Parliament, or by the decision makers themselves, either deliberately or through habits of mind that limit flexibility of thought. Either way, human-imposed limits could be, and sometimes were, broken, but they tended not to be. Such limits and boundaries, whether physical or budgetary, meant that decision makers for the Royal Navy did not have unlimited latitude in creating their ships. Tradeoffs needed to be made. More or bigger guns meant less armor, speed, or endurance, or else a bigger ship and more money. Making these tradeoffs was the core of the development process.

The design process went through three stages between 1889 and 1905. The first stage involved the design of the first two classes built by the Royal Navy during this time, the *Royal Sovereigns* and the *Majestic* classes, as well as the only second-class
ships built during this period, the *Centurions* and the *Renown*. These ships were the result of the first two big building programs; the *Royal Sovereigns* were part of the Naval Defense Act of 1889 and the *Majestic* class was part of the Spencer Program of 1893. The debates over the design of these two classes answered questions about what a battleship looked like—its basic shape and size—and how it would be used under operational conditions to achieve the fleet’s strategic objectives. Decision makers needed to decide if battleships were to be small, heavily armored craft most useful for coastal operations or large, balanced ships suitable for service in the open ocean under all weather.

The nature and effectiveness of the Navy’s system became apparent quickly. Discussion included not just the Board but other senior officers as well, so the decision was made gradually after several rounds of discussion, no doubt with periods of deliberation in between. William White emerged as the primary advocate of larger, balanced, all-weather vessels; Admiral Arthur Hood, the First Naval Lord and as such the senior officer of the Navy, argued for the heavily protected but less seaworthy design.\(^\text{21}\) In the end, something resembling a consensus emerged in favor of the White design. Hood conceded the point, but got something in return: one of the ships was designed and built to his preferences. Wide inquiry for opinion based on experience, a deliberate pace, White’s leadership, consensus, and compromise all led to the form that would dominate battleship design: large, heavily armed, and moderately armored, with moderate speed,

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\(^{21}\) Admiral Arthur Hood, 1st Baron Hood, like Admiral Horace Lambert Alexander Hood (who died at the battle of Jutland), was one of the many members of the large Hood family to achieve high rank in the Royal Navy.
significant range, and the ability to move and fight effectively in the open sea in (almost) any weather.

As complicated as the decisions on the nature of battleships were, the Navy’s leadership also had to wrestle with issues surrounding changes in weapons and armor technology. Broad, general advances in chemistry and metallurgy meant that guns and armor would both be changing, but the practical implications of these changes still needed to be worked out when deciding how the ships were to be built. These were delicate choices, balancing the need for the most up-to-date systems possible with the need for reliable, fault-free systems that could be counted on to work as expected in the harsh environment of sea service and combat. The leadership of the Navy wished for the “best” technology, but was cautious not to reach beyond what could be established as reliable. Navy ships would use the newest technology that was ready, and ready meant both that it had been demonstrated as reliable and effective and that it would be available in sufficient quantities that would not significantly delay the deployment of ships. The fact that the Royal Sovereigns and the Majestics set the pattern for British battleships up to the Dreadnought-- and heavily influenced the design of British and foreign battleships through World War II-- is worth repeating. Despite the apparently significant difference that the all big gun battleship represented, both the basic outline of the battleship design and the process by which ships were designed and approved remained essentially the same. The process by which the product, the battleship, was produced and improved was a product of the period with which this work is concerned.
Once the pattern was set, the Royal Navy entered the second stage, one of gradual improvement on a stable platform. The key issue was continuing the process of improving the battleship and its equipment, while still balancing competing demands. These demands included the limits of physics, cost, and the balancing the need for the most advanced systems available with the need for reliable ships and systems. There was a great deal of room for differences of opinions among the various officers involved in the process. Fortunately, the collegial atmosphere of the senior leadership of the Navy and the deft leadership of William White meant that these differences were manageable and compromise readily achieved.

Mostly, the Navy made incremental changes during the period with which this work is concerned. For instance, a new way of making armor, invented in Germany by the Krupp company, was quickly adopted. Water tube boilers, which promised improved increased efficiency in steam generation and which had been under development in Britain and elsewhere for decades, likewise finally reached the point where they seemed ready for use. Both of these cases demonstrated that the officers of the Navy craved, above all else, empirical information when making decisions. Tests of use, especially competitive tests under operating conditions if possible, were the most valued way to evaluate new equipment and technology.

This situation could not last forever, and the smooth running system eventually broke down. All of the pieces that made the process work came apart at once in one self-reinforcing snafu. At the center of the imbroglio were the self-imposed limits on battleships. The pattern set by the Royal Sovereigns and Majestics had worked well
through the 1890s. However, technological improvements combined with the increasing quality of foreign ships meant that it was no longer possible to “fit” all of the desired capabilities into the ship size accepted as the basic pattern. Debate became appreciably more contentious as it became impossible to accommodate all demands. The Navy was loath to break their limits and increase size (and cost), but it did—though not by enough to resolve the problem of “fit.” Collegiality began to break down as it appeared more and more imperative to win arguments. Decisions became harder to make and were constantly revisited. The process slowed to a crawl. In conditions where leadership was important, the Royal Navy lost its leader in ship design, William White. White’s health, already slipping, was pushed over the edge by a scandal, as the new Royal Yacht suffered a critical stability failure during construction, and while he still enjoyed the confidence of most of the senior leadership of the Navy, he was forced to retire. Thus, there was no guide to sort through the problems associated with the demanded changes.

Ultimately, however, the process and the Navy were resilient enough to overcome the problems. The ability to overcome substantial difficulties is a tribute to the robustness of the process. The College managed to overcome the difficulties and still make informed decisions that created good ships. The ability to do so without William White, the key leader for the previous decades, shows that the system was truly institutional and not tied to the efforts or abilities of one man. The willingness of the senior leadership of the Navy to depart from a successful pattern to meet the demands of new technology demonstrated a willingness to change and adapt.
The Royal Navy had an effective system of designing and developing battleships, and of adopting and incorporating new technology into those battleships. The notion that the leadership of the Navy before Fisher and the *Dreadnought* was directionless and technophobic does not reflect reality. That leadership, cautious under the weight of its responsibilities, had a deep understanding of the limitations of new technology as well as its benefits. It did not lunge forward and adopt the newest thing just because it promised to be better. Instead, it wanted strong evidence that the newest thing could fulfill such promise. The leadership of the Royal Navy may have moved more slowly than strictly necessary at times, but it did avoid the pitfalls of adopting new technology.
Chapter 1:
Strategic Background

Introduction

Great Britain had three strategic goals in the 19th century: home defense, trade security and defense of the empire, particularly India. For the 70 years or so after the defeat of Napoleon the Royal Navy, the world’s preeminent naval force, provided the power necessary to attain these goals. The Navy’s dominance was secured by its mastery of the skills of naval warfare, the availability of British resources needed to create and operate a fleet, and the British political class’s willingness to use those resources. The dominance of the Royal Navy survived the increasingly rapid technological change of the 19th century, which undermined, though did not eliminate, the value of traditional skills of naval warfare, because Great Britain enjoyed a tremendous advantage in wealth and technological development. By the 1880s, however, this advantage began to erode: other states industrialized and concomitantly began programs to improve their own navies, and the increasingly rapid pace of technological change meant Britain no longer held undisputed leadership in the development of new technology. To retain naval dominance, Great Britain needed to build enough ships and to improve its ships’ technology constantly. Beginning in 1889, Great Britain spent a quarter century on an
intense effort to build enough technologically advanced ships to provide for British security.\textsuperscript{22}

A review of the British strategic situation is a necessary starting point for analyzing this effort, beginning with a look at the Royal Navy’s ways and means – its broad operational goals and how it accomplished them. Then, I will summarize the changing diplomatic and military situation faced by the British between 1885 and 1906. In the beginning of this period, the British strove to have a fleet capable of beating any power—particularly France and France’s potential allies—anywhere in the world. Notionally, Great Britain held what was known as the “two-power standard” during the 19\textsuperscript{th} century: its Navy was supposed to be stronger than the next two strongest powers combined. As a practical matter, British naval strength held such a margin of superiority that no formal measure of strength was kept. As it became apparent later in the century that Great Britain could no longer hope to maintain naval superiority everywhere, it began to accommodate potential rivals, to limit potential enemies and perhaps create friends. Finally, the bellicosity of Imperial Germany shifted British focus from its old foe France, and gave Britain a new threat to meet. This was the situation that faced British policy makers responsible for security and drove them to secure ever more technologically advanced and capable battleships to provide safety for Great Britain.

Ways and means

Before examining the strategic situation faced by Great Britain and the Royal Navy, a brief and general overview of the Navy’s responsibilities is in order, as well as a description of the ways and means of operation for the Royal Navy, starting with a brief description of general naval strategic theory. Broadly put, the Royal Navy was responsible for securing command of the sea and denying such command to an enemy once a conflict began. There are two aspects of command: a positive one, enabling your own actions, and a negative one, disabling the enemy’s. On the positive side, command of the sea means freedom to use the seas for communication and transportation, with minimal interference from an enemy. Such command is achieved when enemy warships are either unable or unwilling to operate consistently enough to disrupt the use of that particular part of the sea. Positive command was also achieved by destroying the enemy fleet in battle, if possible. If the enemy refused to fight, blockading it in port was the next best thing.23

The negative command aspect is the converse of the positive: denial of sea use by the enemy. Command of the sea disrupts the enemy’s use and prevents him from freely using the sea for transport or communications. Command is rarely absolute, as raids or covert missions can still be run by the enemy. Command does not prohibit all enemy operations, but it does prevent consistent, predictable, and relatively low-risk use by the

enemy. Command does not mean the enemy cannot use the sea but rather that any use is transient, high-risk and limited.24 In this context, the precursor to command of the sea is naval superiority: the possession of naval forces that are likely, but not guaranteed, to achieve command when conflict begins. Naval supremacy in this context would be the possession of forces with the ability to assume command of the sea effortlessly.25 During peacetime, the Royal Navy sought at least superiority and, if possible, supremacy, which would then be used to assert command of the sea in war.

Securing command of the sea was the essential core of all the tasks performed by the Royal Navy: home defense, commerce protection, commerce interdiction and power projection. The home defense task was the highest priority, as Great Britain had no other effective means of defense. While doubts were raised intermittently during the 19th century about the Navy’s ability to prevent invasion, and while there were occasionally surges of spending on fortifications or enthusiasm for “volunteer” home defense units to defend against invasion, the Navy was ultimately responsible for preventing the conquest of the British Isles in general and the island of Great Britain in particular.26 Home


25 Naval superiority, naval supremacy, and command of the sea are often used interchangeably or with little or no clear distinction between meanings. The definitions presented here are used for this analysis, with the understanding that other usage is not uncommon.

defense required command of the waters around the British Isles, particularly the English Channel. With command held by the Royal Navy it would have been very difficult for an enemy to mount an effective invasion. It might be possible to land armed forces successfully, but it would be very risky. Support for any invading force would be equally risky, as any given support mission might succeed but consistent, predictable support would be extremely unlikely.

Commercial warfare was the second most important function of the Royal Navy, and one that grew in importance as the 19th century went on. Commercial warfare was a combination of offensive and defensive tasks, preventing enemy commerce while at the same time protecting the flow of Great Britain’s. This task often dovetailed with power protection. Commercial warfare as practiced by the Royal Navy meant shutting down the enemy’s commerce by obtaining command of the sea in the relevant region(s). Blockading and intimidation were the key methods. Any ships that were not restrained in port through blockade or intimidation were actively hunted down, and captured or sunk. Command also protected British commercial ships by denying enemy ships the opportunity to attack them. Any enemy warships risking operation in British controlled seas would be rapidly pursued and destroyed, or at least chased back into a blockaded port.


27 Marder, Anatomy, pp 84-104; Gooch, pp. 285-287.
Active convoy protection was also historically part of commerce protection, but was more or less abandoned, though not without some opposition, by the late 19th century. Critics called it “too defensive” and claimed it was impossible to keep steam powered merchant ships (unlike sailing ships) in proper convoy formation. This was primarily because steam ships had a wider variation in speed than sailing ships had, and because British naval officers doubted the ability of merchant captains to maintain formation. This makes little sense, as steam ships were generally easier to keep on a specified course and speed, especially in conditions where they were moving contrary to the prevailing wind and current. The decision to abandon convoys turned out to be the wrong one, as actual practice in World War I demonstrated.

The Navy had different types of ships to handle various roles. As noted, the Royal Navy’s primary task was to obtain and defend naval command, that is, freedom of action, and to prevent enemy navies from doing the same. This was essentially the first step in the execution of the Navy’s responsibilities. Traditionally, this task was performed by fleets composed of sailing ships of the line, which were replaced during the third quarter of the 19th century by steam driven iron and ironclad ships. These ships had a combination of gun power and toughness that could only be challenged by their counterpart battleships in other navies. Other ships might be fast enough to run away, but they could not prevail in combat. Smaller ships, first frigates and similar vessels, which

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were later replaced by cruisers and related types, supplemented the battleships. They acted as scouts, pickets, and messengers for ship of the line or battleship fleets. These fleets were responsible for blockading ports and destroying enemy fleets, which provided defense against invasion and left the seas clear for smaller British ships and commerce. Cruisers—smaller, faster, and sometimes with more endurance—also played an active role in protecting British shipping and hunting enemy commercial ships.²⁹ If British battleship fleets had been successful in destroying or intimidating enemy fleets early in a conflict (and they generally were), cruisers could perform their tasks without fear of being overwhelmed by the enemy’s battleships.

The invention of the automobile torpedo in 1868 began to complicate this picture, by making battleships vulnerable to much smaller craft than could previously challenge them. Certain tactical adjustments, however, helped protect battleships from torpedoes. They included adding light guns to ship designs specifically to protect against torpedo boats, as well as the development of torpedo boat destroyers (later simply called destroyers), small craft specifically designed to escort battleships and protect them from torpedo boats. So while the composition of the Navy as a whole changed somewhat, the basic division of labor remained intact. Fleets of battleships supported by auxiliary

²⁹ British trade protection cruisers often carried full sailing rig to provide endurance away from coaling stations, even as late as the 1870s, or were provided with a generous coal supply to extend range. See David K. Brown, From Warrior to Dreadnought: Warship Development, 1860-1905 (London: Caxton Editions, 2003), pp. 105-113, 135-136; William Hovgaard, Modern History of Warships (Annapolis: Naval Institute Press, 1971), pp. 164-226.
vessels controlled the enemy’s fleets, while smaller vessels went about their responsibilities.

In peacetime, the array of ships and the reputation of the Royal Navy served as a deterrent to any power that was considering military action against Great Britain. While acting as a deterrent force, the Navy also served other functions in furthering British foreign policy. It suppressed the slave trade, provided emergency and humanitarian assistance, protected British persons and property threatened by violence, mounted punitive expeditions against recalcitrant local rulers, showed the flag and presented the not completely inaccurate picture that British power was everywhere.³⁰

Setting the table: British strategic situation in the 1880s

Great Britain’s defense commitments were very large by the 1880s. Britain had bases and ships deployed worldwide in a largely successful effort to maintain sufficient naval power to gain naval superiority anywhere.³¹ The burden of defense was increased by British foreign policy. “Splendid isolation,” the refusal to enter into long-term commitments or alliances with other powers, gave Great Britain great freedom for diplomatic maneuvering, but also precluded counting on any other state for assistance.


³¹ Paul Kennedy, The British Naval Mastery, pp. 154-155, 177-178.
Great Britain thus created a strategic situation where it had very extensive commitments that it had to meet on its own.\textsuperscript{32}

Britain’s most consistent rival up to the 1880s was France. The 18\textsuperscript{th} and 19\textsuperscript{th} centuries had been dominated by their political, economic, and military rivalry. France had the second largest navy in the world and was Great Britain’s main colonial competitor. Its geographic position was such that it could threaten both an invasion of Great Britain and interdiction of British commerce in the Atlantic and the Mediterranean. France’s Mediterranean coast also made it a threat to British communications with India. France’s worldwide interests, while not nearly as extensive as Britain’s, were almost as geographically diverse, which meant that France could potentially be a danger to almost any part of the British Empire.

Russia was Great Britain’s second biggest security concern. Russian penetration of Central Asia brought it ever closer to India. While some dismissed the threat of an overland attack on India because it would be logistically impossible to support, on the whole the British political and military establishments took the threat very seriously.\textsuperscript{33} The growth of Russian influence in the Far East, particularly in China, was also a concern. On the naval side, Russia was not a concern by itself, but in combination with another power (namely, France) it could cause serious difficulty.\textsuperscript{34}


\textsuperscript{33} Monger, pp. 3-4.

\textsuperscript{34} Marder, \textit{Anatomy}, pp.131, 153-154, 162-163, 181-182, 238-240, 257; Monger, 3-7.
Though no single power was in a position to be a direct threat to Great Britain in the 1880s, British policy makers feared an offensive combination of multiple powers. Russia, Italy, or Germany might combine with France, or another power might take advantage of Britain’s committing forces elsewhere, particularly against the United States. This might stretch the Navy too far, resulting in weaknesses that could be taken advantage of.³⁵

Despite the significant commitments and a potentially large number of opponents, British defense budgets were not large. By the mid-1880s, Great Britain had kept new construction to a minimum for most of the past fifteen years. The general parsimony of the government when not faced with an immediate threat was the key driver here. Both Liberals and Conservatives generally frowned on large government expenditures, with the Liberals especially hostile to military spending.³⁶ To complicate matters, rapidly changing technology made the 1860s through the 1880s a period of great uncertainty for ship design.

Shipbuilding was still done primarily by judgment based on experience, as opposed to knowledge derived from theoretical understanding of physical principles. There was little scientific theory about stability, dynamic structural loading, or how ships


moved through the water and waves. Builders of wooden ships had learned which forms worked well and were stable through trial and error. There was yet little scientific understanding of many of the underlying principles from which practical solutions to design problems could be derived. As the technology changed, older knowledge about what constituted a “good” or “safe” design became obsolete and thus needed to be replaced, and either experience with new materials and technology or theoretical knowledge was required. Both took time to develop. In the meantime, there were sometimes substantial differences of opinion over what was a safe and effective design, and these debates sometimes broke out into sharp arguments, leading to designs built primarily to prove a point. Still, opinion was generally based on basic shipbuilding knowledge and experience to some extent, though it was also influenced by fashion. Thus tradition, and to a degree axe grinding, determined design. The result was a series of ships that could almost be described as “experimental,” as the ideal ship type changed with the personnel making the decisions.\textsuperscript{37} Given this level of uncertainty, the government wished to avoid investing large sums in ships that would have been unsuccessful designs or that would be eclipsed too quickly.\textsuperscript{38}

The Navy and the government became more willing to increase construction budgets by the mid-1880s. Other states were beginning to build up their navies after years of neglect. By 1883 France’s naval construction budget had been equal to Great


\textsuperscript{38} Marder, \textit{Anatomy}, pp. 123, 125-126.
Britain’s for six years. Russia was also in the process of expanding its navy, and even Italy and Germany were engaged in naval expansion programs. The Royal Navy was beginning to decline in relative, if not absolute, strength. With its military power at a relative low, Great Britain’s diplomatic situation was deteriorating. The British Government and naval leadership were confident of victory against a single power, but were worried that the Navy failed to meet the informal two-power standard. British relations with France, Russia, and Germany deteriorated badly at the same time, in 1884. The diplomatic situation was so poor that rumors of a continental maritime league began to circulate—which would have meant that Britain would need to engage not two but possibly three powers.\textsuperscript{39}

Amidst these rumors, a series of articles entitled “The Truth About the Navy” by “One Who Knows the Facts” appeared in the \textit{Pall Mall Gazette} in September of 1884, and set off a public storm. Written by editor W. T. Snead and based on information supplied by individuals with ties to military services, including Captain John A. “Jacky” Fisher, the articles revealed both qualitative and quantitative failings of the navy.\textsuperscript{40} The political pressure for action became intense, and in response the government introduced the Northbrook Program, named after the First Lord of the Admiralty, the ministerial head of the Navy, to spend an additional £3.1 million to build twenty-seven ships,

\textsuperscript{39} Marder, \textit{Anatomy}, pp. 120-121.

\textsuperscript{40} Marder, \textit{Anatomy}, p. 121; and Parkes, p. 328.
including two battleships.\textsuperscript{41} More importantly, the agitation surrounding “The Truth” initiated a lasting level of public interest in the state of the Navy.\textsuperscript{42}

\textit{Against All Comers}

While the public was taking a more sustained look at the Navy, the Navy was beginning to take a serious look at itself. In 1887 Sir William H. White, Director of Naval Construction (DNC), had submitted a comprehensive assessment of ship needs, including a list of obsolete ships that would soon need to be replaced, and proposed a building program to replace them. While the response to his building program was initially mixed, the number of obsolete ships needing replacement could not be denied.\textsuperscript{43} The Admiralty also determined to look closely at the 1888 naval maneuvers and assess the fleet’s readiness for war. It did not like what it saw: a report by three widely respected admirals declared the fleet “altogether inadequate…to take the offensive” against a single power, and against an alliance “the balance of maritime power would be against England.”\textsuperscript{44}

\begin{itemize}
\item[	extsuperscript{41}] Marder, \textit{Anatomy}, p. 122; and Parkes, p. 328.
\item[	extsuperscript{42}] Marder, \textit{Anatomy}, p. 45; Kennedy, \textit{British Naval Mastery}, pp. 178-179.
\item[	extsuperscript{43}] Brown, \textit{Warrior to Dreadnought}, pp. 124-125.
\item[	extsuperscript{44}] William H. White, “Financial Plan of Special Program,” The National Archives: Public Record Office (TNA: PRO) CAB 37/22/30, (Records of the Cabinet: Cabinet Minutes and Papers), Marder \textit{Anatomy}, p.132, Brown, \textit{Warrior to Dreadnought}, p. 125; Parkes, p. 352. The three admirals were Dowell, Vesey Hamilton and Richards; the latter two later served as First Naval Lords.
\end{itemize}
Naval and public opinion were united, and action followed. Lord George Hamilton, who replaced Northbrook as First Lord, placed the Naval Defense Act before Parliament in March of 1889. It provided for a large ship building program totaling 68 ships, including eight first class battleships, two second class battleships, forty-two cruisers, and eighteen torpedo boats. Its scale and importance was underlined by the fact that it committed the government to future spending, a significant breach of the custom that one year’s parliament did not commit subsequent parliaments to expenditure.\textsuperscript{45}

The Naval Defense Act also defined the political and strategic goals of the British government that would drive naval policy for the next twenty-five years. In his speech introducing the Act, Lord Hamilton formally committed Great Britain to the informal but previously neglected “two-power standard” of naval armaments, effectively committing it to equal the combined strength of France and Russia.\textsuperscript{46} While it was never explicitly stated, fleet strength referred to first-class battleships, those considered the newest, most modern, and most powerful ships. These ships secured command of the sea and allowed the rest of the fleet freedom of action. This created some problems, because the range of ship ages and the constant changes in naval design and technology created some debate over exactly which ships counted as first-class and which had slipped into obsolescence and second-class status. There was also an expectation for the number of auxiliary ships, cruisers, and similar vessels to be well in excess of the combined strength of the next two

\textsuperscript{45} Marder, \textit{Anatomy}, 143; Brown, \textit{Warrior to Dreadnought}, p. 125.

powers. Command of the sea orthodoxy aside, British trade and other overseas commitments demanded those extra ships to ensure protection.\textsuperscript{47}

The formal announcement of the “two power standard” had its roots in two areas. The first was politics. There had been much public discussion over the previous few years on the state of the Navy, and the government wished to reassure the public that it would not “neglect” national security.\textsuperscript{48} Second, the statement was intended to deter other powers from attempting to threaten British Naval dominance by announcing that Great Britain would build whatever ships necessary to maintain the relative strength of the Navy.\textsuperscript{49} That Lord Hamilton, undoubtedly with the backing of the cabinet, thought it necessary to make such an announcement indicated awareness that conditions had changed, and that Great Britain would soon have to work significantly harder than it had in some time to maintain its naval position.

Unfortunately for Great Britain, Prime Minister Lord Salisbury was correct when he predicted that the Naval Defense Act would fail to deter other countries from naval construction and instead would mark the beginning of British involvement in a naval arms race.\textsuperscript{50} No other power was intimidated by the increased size of the Royal Navy, and France, Russia, Germany, Italy, the United States, Japan and even several smaller

\begin{flushleft}
\textsuperscript{47} Marder, \textit{Anatomy}, p. 106.


\textsuperscript{49} Brown, \textit{Warrior to Dreadnought}, p. 125.

\textsuperscript{50} Marder, \textit{Anatomy}, p. 143.
\end{flushleft}
countries, notably those in Latin America, all added to their fleets over the next decade, not infrequently by purchasing state of the art battleships and cruisers from British shipyards.\textsuperscript{51} Increasingly, almost all the world powers saw naval strength as necessary for security and as powerful leverage against potential foes, and states launched ever-larger ship building programs in order to secure naval strength. Great Britain felt compelled to respond to these successive foreign building programs with its own, to maintain its maritime security. Soon, Britain needed to follow up the Naval Defense Act with an even larger program, the Spencer Program, named after the First Lord who succeeded Lord Hamilton, and even this was not enough. Great Britain was engaged in a constant, sustained shipbuilding effort.

Dealing with the potential of the new Franco-Russian alliance was the most important strategic naval issue for British policy makers and the leadership of the Royal Navy, from 1890 until the German threat replaced it sometime between 1900 and 1907.\textsuperscript{52} Home defense was always an issue, and the possibility that France would launch a surprise invasion from its ports just on the other side of the English Channel, while the bulk of the Navy was distracted or inactive, was never far from the minds of Royal Naval leadership. However, this was usually an issue of worst-case planning and was not regarded as a serious problem, at least not by the Navy.\textsuperscript{53} Far more serious problems

\textsuperscript{51} Friedberg, pp. 152-167.

\textsuperscript{52} Marder, \textit{Anatomy}, pp. 65-455, 547-579, provides the definitive description of British Naval policy at this time.

\textsuperscript{53} Marder, \textit{Anatomy}, pp. 65-83, 320-335.
involved commerce protection and the defense of the Mediterranean Sea with its line of communications to India. Commerce protection was only slightly less important than protection against invasion. Any interruption of trade would have been devastating to the British economy and, even more importantly, any interruption in the food imports upon which Britain was extremely dependent threatened hunger and social collapse.\textsuperscript{54} In the Mediterranean, the danger that the Russian Black Sea Fleet might be able to capture the Turkish straits suddenly, enter the Mediterranean, and unite with the French fleet to drive out an outnumbered Royal Navy, provided a very difficult planning problem.\textsuperscript{55} Maintaining adequate fleet strength for commerce protection, along with the defense of the Mediterranean and home waters, proved difficult and forced Britain to build more ships.\textsuperscript{56}

French and Russian naval power could also be an issue in the Far East, based on French imperial bases in Cochin China and the Russian base at Vladivostok. The concurrent Japanese naval expansion complicated this issue. While Japan was not considered hostile, as the two countries shared a mutual interest in containing Russian ambitions, the leadership of the Royal Navy thought it necessary to be able to maintain superiority over Japan. The perceived need for newer ships for the Far East Station and the desire to be able to reinforce it quickly contributed to the building plans for the

\textsuperscript{54} Marder, \textit{Anatomy}, pp. 84-104.

\textsuperscript{55} Marder, \textit{Anatomy}; Sondhaus, p. 169.

\textsuperscript{56} Marder, \textit{Anatomy}, pp. 144-240.
second class battleships of the Naval Defense Act in 1889, the Renown in 1892, and the Canopus class in 1896.\textsuperscript{57}

By the end of the century, Great Britain had achieved a certain level of security against Franco-Russian naval power. Neither France nor Russia was able to build the quality or quantity of ships that they had planned within the timetables set. Delays were endemic. Political shifts created constant changes in French naval policy, which disrupted construction, and money problems plagued both countries, causing some construction plans to be dropped. Russia also suffered from inadequate technical and industrial capabilities, and consequently produced ships that were inferior in both number and quality to those planned and announced. Yet both navies did produce ships, forcing Great Britain to build still more ships to maintain the two power standard in battleships and the even larger preponderance in small vessels.\textsuperscript{58}

However, staying ahead of France and Russia did nothing to alleviate other threats: the growing Italian, Japanese, German, and American navies. None were a match for Great Britain alone but any could decisively shift the balance of naval power

\textsuperscript{57} Ships Cover No. 146, Canopus class, National Maritime Museum (NMM); Marder, Anatomy, pp. 238-240; Brown, Warrior to Dreadnought, pp. 131-132;

against Britain either regionally or if united with France and Russia. The construction of a small but very efficient German fleet in home waters was particularly disturbing. More aggravating still was its spur to France and Russia to increase the size of their navies even further. Even Brazil, Argentina, and Chile began naval build-ups, which meant the Royal Navy would need substantial reinforcements to maintain local superiority.

British naval planners strove to build enough ships to meet all of the Royal Navy’s potential obligations, and the Naval budget skyrocketed. While Great Britain could have, in theory, paid the cost of building and operating enough ships to meet all of the demands placed on the Navy, the political will was not there. Because Great Britain no longer possessed the overwhelming financial or industrial superiority it held at mid-century, supporting a naval program sufficient to maintain superiority against any combination of powers anywhere was no longer an easy burden. The taxes necessary to support such a fleet were not possible in the political climate, and neither party was willing to propose them.


64 Friedberg, pp. 89-92.
Complicating this picture were very serious British concerns about the significant Russian pressure in Central Asia, particularly in Afghanistan and Persia, and the resulting security threat to India. The greatest danger from Russia was not its navy, but the perceived possibility of an overland invasion of India, particularly given the growth of Russian rail lines into Central Asia. The Army’s demands for reinforcements to meet such an invasion were very costly and completely politically unsupportable.

The End of Isolation

The British government faced an immense dilemma: its security commitments were greater than the resources available to meet them. The naval budget in particular almost

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65 Friedberg, pp. 209-278, Keith Wilson, The Policy of the Entente (Cambridge: Cambridge University Press, 1985), pp. 6-7, 15; Monger, pp. 3-6; Kennedy, British Naval Mastery, p. 197; Marder, Anatomy, 302-311

66 Friedberg, p. 209-278; Wilson, p. 15,

doubled between 1889 and 1899 as the Navy built more and more expensive ships, and further increases were expected. The Boer War (1899-1902) cost over £200 million, almost two years of total normal government expenditure, mostly for the army. Indirect taxation was thought to be at its limits without protectionist tariffs and income and other direct taxes, while low by modern standards, were also thought to be at their political limits. It was still not enough to meet obligations, and both services pressed for additional money. Britain could no longer afford splendid isolation or to maintain naval superiority everywhere at all times. Military needs would have to be prioritized more carefully, and potential threats be reduced by diplomacy. The highest priorities were European waters for home and trade defense, India, and the lines of communication to India. The Royal Navy focused its resources here, while withdrawing from other commitments.

This process was underway by 1900 in the Americas. Relations with the United States improved with a series of diplomatic concessions after 1895. The Navy was it difficult, within the perceived political constraints of the time, for Britain to retain superiority at sea everywhere at all times. This study takes a similar position.


69 Sumida, table 1; Friedberg, pp. 106-107, 130-132.

70 Monger, pp. 8-14.


72 Kennedy, British Naval Mastery, pp. 211-212. The two most important issues were the dispute over the boundary of Alaska, settled on terms favorable to the United States, and the concession that the United States could build and fortify an isthmian Central
partially responsible for this development, as it refused to deploy additional ships to the Caribbean during the 1895 crisis over the disputed boundary between Venezuela and British Guyana, because of the necessity of retaining ships in European waters. The British Cabinet acknowledged that it would be impossible keep ahead of the growing industrial and financial might of the United States. Canada and the Caribbean could only be defended by drastically weakening the Royal Navy in European waters, once the United States Navy had begun its naval expansion, and the British government, led by Lord Lansdowne after he became Foreign Minister in 1900, soon gave up the pretense that it could do so. Besides, many British political and military leaders had also developed an emotional and ideological attachment to the United States and looked at it as a natural ally. There was even intermittent talk of an alliance or other forms of close naval cooperation between 1894 and 1905 by prominent Americans and Englishmen, well received by many naval officers but not by the Admiralty. The British could not

American canal alone, contrary to the Clayton-Bulwer Treaty of 1850, which required cooperation. The British had also looked sympathetically on American efforts in the Spanish American War and applauded its colonial/imperial growth into the Caribbean and Philippines.

73 Gooch, p. 289.

74 Gooch, p. 289; Kennedy, British Naval Mastery, pp. 216-217.

75 Kennedy, British Naval Mastery, p. 211; Marder, Anatomy, pp. 442-450; Gooch, p. 289.

compete with the United States in the Americas and no longer cared to try, so resources were shifted elsewhere.  

Britain likewise might have been reconciled with Germany, but ultimately was not. Relations with Germany around the turn of the century were a mix of good feelings and irritation. Initially, it appeared that the good feelings would triumph over the irritation, and Britain would at a minimum come to an understanding with Germany and perhaps enter the Triple Alliance. Joseph Chamberlain, Colonial Secretary from 1895 to 1906 and perhaps the most dynamic member of the Cabinet, began pressing for an agreement with Germany in 1898, even beginning informal and unofficial talks with the German Ambassador. Chamberlain had some support in the Cabinet, and continued his efforts until 1902. Growing Russian pressure on China after 1900 further encouraged Britain to move closer to Germany. While some Germans were receptive, notably Baron von Eckardstein, the German chargé d’affaires in London who offered Great Britain a general defensive alliance on his own initiative in early 1901, the German government did not make any real gestures of compromise that might have encouraged Britain.


78 Monger, pp. 14-16.

79 Monger, pp. 21-45.
Additionally, Lord Salisbury, Prime Minister from 1895-1902 and Foreign Minister from 1895-1900, had very little trust in German intentions.\(^{80}\) In this he was supported by the professionals in the Foreign Office, most of whom were ardent Germanophobes and distrusted Germany even more thoroughly than he did.\(^{81}\) King Edward VII, who strongly disliked his nephew the Kaiser and consistently favored Foreign Office professionals who shared his opinion, further reinforced dislike of Germany after 1901.\(^{82}\) As yet, dislike of Germany was a minority opinion within the British elite, even if it was an important minority.

Most official concern about a security threat by Germany was preceded by an increase in Germanophobia in the general public.\(^{83}\) The Krueger telegram and German hostility during the Boer War antagonized British public opinion.\(^{84}\) Further, much to the surprise of officials, the public met cooperation with Germany over the matter of Venezuelan debts in 1902 with hostility.\(^{85}\) The rapid growth of the German economy and German economic competition also became an issue for parts of the public. Competition for export markets and resentment of German protectionism soured public

\(^{80}\) Monger, pp. 17-20.


\(^{82}\) Monger, pp. 101; Kennedy, *Anglo-German Antagonism*, pp. 255.

\(^{83}\) Monger, pp. 17-20; Kennedy, *Anglo-German Antagonism*, pp. 255-257.

\(^{84}\) Kennedy, *Anglo-German Antagonism*, p. 231; Marder, *Anatomy*, pp. 256, 459.

\(^{85}\) Monger, pp. 105-107.
opinion. German economic activity in the Ottoman Empire, especially the Berlin-
Baghdad railway project, which would have given Germany easy access to the Persian
Gulf—an area the British thought of as in their sphere of interest and one important for
the defense of India—also created tension. In many ways these issues were just the
normal friction between two Great Powers pursuing their own interests and, while they
soured relations, they would not have in themselves created an unmanageable rivalry.86

A more serious issue was the growth of the German Navy. The First and Second
German Naval Laws of 1898 and 1900 began the creation of a substantial German fleet
of battleships. While the German government cloaked the new navy as a defensive
measure to protect its growing overseas trade, its real purpose was to challenge the
supremacy of the Royal Navy by creating a fleet powerful enough that the Royal Navy
could not confront the German Navy without fatally weakening its ability to defend
Britain against other foes. Britain would thus be forced to come to a political
accommodation with German Imperial ambitions. This was the “Risk Theory.”87

The British Government and the Navy viewed Germany’s fleet buildup as
targeted directly at them. Rear-Admiral Reginald Custance, Director of Naval
Intelligence (DNI), reported as early as December of 1900 that the German Navy would
be larger than the Russian by 1906, and that the North Sea would need to be defended.88


88 Kennedy, Anglo-German Antagonism, pp. 251-252
First Lord Selborne circulated a memo to the cabinet in 1902 stating that the short range of German battleships, as well as other intelligence, indicated that the only possible target for the new German Navy was the Royal Navy.\textsuperscript{89} Much of the press identified the German navy as a direct challenge, as did others in the British military and political establishment.\textsuperscript{90} Arthur Marder claims that by the autumn of 1902, public opinion agreed with the Navy and the government that the German fleet was more dangerous than those of France and Russia.\textsuperscript{91} Marder also cites a claim from Captain H. Taprell Dorling that, on what Dorling called the “very highest authority,” that the Naval Intelligence Division (NID) had considered Germany “Britain’s most probable enemy” by 1900. John Gooch also indicates that 1900 was the year NID drew this conclusion, and while he does not cite either Dorling or Marder it seems likely that he drew from one or both of them.\textsuperscript{92}

This claim, however, is highly debatable. Dorling was a retired naval Captain who served with distinction in World War I and World War II and wrote mostly fictional maritime and naval adventure books under the pseudonym “Taffrail.” He also wrote on service medals and reward recipients, plus a few non-fiction works on naval topics.\textsuperscript{93}

\textsuperscript{89} Marder, \textit{Anatomy}, citing a memo from First Lord Selborne, p. 462.

\textsuperscript{90} Marder, \textit{Anatomy}, pp. 458-465; Kennedy, \textit{Anglo-German Antagonism}, p. 251.

\textsuperscript{91} Marder, \textit{Anatomy}, p. 465.


\textsuperscript{93} His adventure stories include, for example: H. Taprell Dorling, \textit{White Ensigns} (New York: G.P. Putnam’s Sons, 1943); H. Taprell Dorling, \textit{Sea, Spray and Spindrift}, Naval
Dorling certainly had an insider’s knowledge of the navy and undoubtedly would have had connections within the navy, perhaps even well enough placed to know the thinking of the Naval Intelligence Office in 1900. However, he was not a historian or scholar but rather a popular author who provides no substantiation for his claim. Two issues could cast reasonable doubt on his assertion. First, either he, or more likely his source, could have made such a claim after the fact to enhance his reputation by making it seem that he had known of the German threat before it happened. Second, memory can be unreliable. It would be possible for Dorling’s source to “remember” such an occurrence if something related happened, or even if it did not happen at all. Similarly, Dorling also could have “remembered” such a report inaccurately. While Marder does cite him, he does not really endorse him, instead using him as just another piece of evidence for his argument.


Without more supporting evidence, such a claim must be taken very cautiously and while it cannot be dismissed outright, it cannot be accepted as correct.

In Marder’s view, both the redeployment of the Royal Navy into northern European waters, begun in 1904, and the entente with France concluded later that same year were results of the German threat. Britain withdrew ships from its most distant posts and concentrated its Navy in Home waters to face the German navy across the North Sea. The entente with France was to resolve outstanding issues so that Britain could concentrate on defending against Germany without worrying about a potentially hostile France.95

This interpretation has been predominant for years. However, it is incorrect. The redeployment of the fleet reflected the focus on the security priority of European waters, and the diplomatic agreements with France were just part of the larger effort to improve British security through diplomacy. The British government and the leadership of the Royal Navy were indeed worried about the German navy. They remained more worried, however, by France and Russia.96 France still had the largest navy in the world after Britain, was located in a dangerous strategic position across important lines of sea

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communication in the North Atlantic and Mediterranean, and could call on Russian help. The German navy may have been able to tilt the scales against Britain in cooperation with other powers, but the French navy was by far the greater weight on those scales. Additionally, Britain was at odds with France over a host of colonial issues, and the two states had been intense rivals for two centuries. France was still the greatest overall worldwide threat to British interests; Germany was but a mild annoyance.

Russia, too, remained a higher priority than Germany for British security planners right after the turn of the century, and British diplomats looked for help in East Asia. This led to the most formal and radical departure from “splendid” isolation: the defensive treaty with Japan, first signed in 1902. The rapid growth of French and Russian naval power in the Far East was a significant problem that seemed impossible to overcome without weakening the fleet in European waters—which was not acceptable. In addition, Japan was building up a large modern fleet, which needed to be accounted for in calculating naval needs. However, Japan too was alarmed at the growing Russia presence in China and Korea. Japanese efforts to come to an agreement with Russia on spheres of influence in northern China were not successful, due to Russian unwillingness to compromise, and so Japan was quite interested in coming to an agreement with Britain. The Anglo-Japanese Alliance committed the two countries to come to one another’s aid if attacked by more than one other power. This effectively neutralized any potential threat posed by the Japanese fleet, at least in the short to medium term. It also provided an

97 Marder, Anatomy, pp. 428-429.

98 Ships Cover Number 146, Canopus class, NMM
important ally in the region if war with France and Russia ever became an issue.

Initially, the agreement signaled only that Britain had conceded it could not stay supreme in the Far East. Within a few years, though, the British withdrawal of naval strength, while not quite as thorough as in American waters, was enough to concede the region to Japanese control.\(^9\)

The Japanese alliance paid dividends above and beyond redressing British naval inferiority relative to the Franco-Russian alliance in East Asia. The Russo-Japanese War in 1904-1905 was a sweeping success for Japan and a disaster for Russian arms. Japan almost wiped out the Russian navy: every Russian battleship and large cruiser outside of the Black Sea was either captured or sunk by the Japanese navy in far eastern waters. This eased the threat from the Franco-Russian allied naval forces considerably; France would be on its own for years. The Russian army was not smashed as badly as the navy, but it had taken a drubbing. The loss of the war and the political turmoil of the Revolution of 1905 further undercut the Russian military and relieved some of Britain’s security concerns in both the Far East and Central Asia, at least in the short term.\(^{10}\) In the longer term, Russia had not yet given up its ambitions in Central Asia, but it was willing to reduce tensions. Britain remained seriously concerned about Russian

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\(^{10}\) Marder, *Anatomy*, pp. 435-441; Monger, pp. 175-184, 199-202
capabilities, so both sides looked toward compromise. The Royal Navy was free to withdraw its last battleships from the Far East.

The most important improvement in British diplomatic and security positions, though, concerned France. Relations with France began to brighten in 1903, as attitudes toward France changed among the general public and among key members of the British government. Starting at the top, the death of Victoria and ascension of Edward VII in 1901 replaced a Germanophile Queen with a Francophile King. Thus, the personal influence and preference of the Monarch shifted from favoring Germany and distrusting France to the other way around. Edward’s visit to France in 1903 was well received and helped pave the way for governmental talks.

Diplomatically, Foreign Minister Lord Lansdowne made conciliatory gestures in Siam (Thailand) and Malaysia in Asia, and in Morocco. At this juncture, in July 1903, French President Émile Loubet and Foreign Minister Théophile Delcassé visited Britain. Delcassé, always looking for partners against Germany, signaled that France would be amenable to negotiations and compromise over certain touchy colonial questions, including Egypt and Morocco.

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102 MacKay, p. 345.

103 See Kennedy, *Anglo-German Antagonism*, p. 400, for a summary of Queen Victoria’s moderating influence on the government’s reactions to Kaiser Wilhelm’s erratic behavior.


105 Monger, p. 127.
Delcassé also hinted that France might be able to restrain Russia.\textsuperscript{106} The increasing tension in the Far East, where new British ally Japan and old French ally Russia seemed headed for a collision, made the British Government more receptive to such approaches, and by April 1904 Britain and France had signed the entente covering a range of imperial issues, especially Morocco and Egypt.

Despite this understanding with France, British security policy makers still regarded it as a potential foe. Britain’s initial redeployment of the fleet did not station the ships in Britain but at Gibraltar, where they could go north to defend the Channel or east to combine with the Mediterranean Fleet stationed at Malta.\textsuperscript{107} France, not Germany, was the potential threat in the Mediterranean. Later in 1904, First Lord Selborne wrote in a December memo assessing the naval strength of various powers that “the French Navy stands, as always, in the forefront.” While he did not overlook the growth of the German navy, Selborne did not focus on it. He reaffirmed the strategic threat of France.\textsuperscript{108}

There is also the matter of Admiral John “Jackie” Fisher’s appointment as the new First Sea Lord in October of 1904. Arthur Marder has portrayed this as a move to prepare the Royal Navy for the growing German threat, the same way he portrays the fleet redistribution.\textsuperscript{109} Jon Sumida and Nicholas Lambert assert that Fisher was

\textsuperscript{106} Monger, pp. 128-129.

\textsuperscript{107} Mackay, pp. 342-343

\textsuperscript{108} Quoted in Mackay, p. 344.

\textsuperscript{109} Marder, Anatomy, pp. 483-545; Marder, Dreadnought to Scapa Flow, vol. 1, pp. 14-70.
appointed primarily because he was willing to cut the naval budget. In addition, Fisher’s plans, as described in “Naval Necessities,” his lengthy memo to First Lord Selborne, are very much aimed at the French/Russian alliance and naval dangers. Fisher was very concerned with trade protection and central to his plans were his new armored cruisers, the battlecruisers, which were to “gobble up” enemy commerce raiders. While Marder asserts that the Dreadnought was to be the central idea of Fisher’s new fleet to face Germany, newer interpretations identify it as only the showcase and proving ground for concepts intended for the battlecruisers.110 Only later, after the initial fleet redistribution and further developments in 1905, did Fisher trumpet his plans as directed at the growing German threat.111

The strategic realignment of the British Navy was an outgrowth of the diplomatic and political changes brought about to decrease the defense burden on Britain. The policy was designed to improve British security in European waters against whatever foe might challenge Britain. Hindsight makes it appear to be a specifically anti-German measure, when in reality it was a general measure to improve security in the highest priority area for Britain: its home waters.

In a relatively few years then, Great Britain had improved its strategic situation immensely by deft diplomacy. Great Britain would follow up with an entente with


111 Friedberg, p. 191.
Russia in 1907, improving its diplomatic and security position even further. Michael Howard summed it up by saying: “It added up to quite a remarkable feat of diplomatic pacification. In 1901 the British Empire had stood alone in unpopular isolation. By 1908 she was on increasingly friendly terms both with her traditional rivals, France and Russia, and with the new naval powers on the other side of the world, the United States and Japan.”¹¹² The British Government, which faced multiple strategic threats that created a defense burden it could not afford, used compromise and concession to sharply reduce the security threats to Britain and the Empire.

This did not mean that naval planners thought the diplomatic progress had solved all of the strategic problems Britain and the Royal Navy faced, at least not yet. The senior officers of the Royal Navy were still cognizant of the fact that the diplomatic situation could change, and that France and Russia could once again become concerns. A Board of Admiralty memo from February 1906 stated, “‘ententes’ may vanish–battleships remain.”¹¹³ However, the one great naval power with which Britain had been unable to come to a diplomatic accommodation, Germany, soon pushed all other strategic concerns aside.

_The Dreadnought, the German Problem, and the Anglo-German Naval Race_

The construction, launch and commissioning of the _Dreadnought_ in 1905-1906 marked a turning point. The _Dreadnought_ itself was a qualitative leap forward, and set a new

¹¹² Howard, p. 30.

¹¹³ Cited in Monger, p. 310; see also Mackay, pp. 345-346.
pattern for battleship design. However, the *Dreadnought* also marked (but did not create) another turning point; the replacement of France by Germany as the number one strategic threat to Great Britain and the Royal Navy. The relative importance of Germany as a threat was the result of a combination of the above mentioned decline in the likelihood of security threats from other sources, the increasing concern about German aggressiveness in general, and the continuing growth of the strength of the Imperial German Navy in particular. Only in late 1905 or early 1906 did these issues surpass older strategic dilemmas to take first place among British strategic and naval planners.

The Moroccan crisis of 1905 called attention to German bellicosity. German grandstanding in Morocco, intended to break up the new *entente* between Britain and France, backfired and brought them closer together. For many, it confirmed the pattern of aggressive German rhetoric and antagonistic German diplomacy, and convinced doubters that Germany was indeed not just a minor threat but rather the primary security threat to the British Empire. Germany, many believed, was planning to overthrow the existing order—by bluster and intimidation if possible and by force of arms if not. British naval

supremacy in European waters, that is, Britain’s ability to assume command of the sea at will, was part of that order, and was now seen to be under threat from Germany.\textsuperscript{115}

The Supplemental Naval Law of 1906 provided the funds that launched the Imperial German Navy into the dreadnought race and made it absolutely clear to all observers that the Imperial German Navy existed to challenge the Royal Navy.\textsuperscript{116} Great Britain would not stand by and watch naval superiority, and with it its security, pass from its hands. It proceeded to ensure that its own battleship building program continued to provide a sufficient margin over German building to maintain the quantitative superiority of the Royal Navy. In addition to numbers, both Navies introduced qualitative improvements to try to gain an edge. The Anglo-German naval race became the classic arms race of the early 20\textsuperscript{th} century.

\textit{Conclusion}

For most of the 19\textsuperscript{th} century, Great Britain had little difficulty defending its main interests: home defense, commercial network, and the Empire, particularly India. Great Britain possessed the combination of the needed skills, resources, and willpower to keep its navy supreme. By the 1880s its relative lead in the skills and resources needed to sustain the fleet had started to weaken. Other powers began to “catch up” economically and technologically with the leader of the industrial revolution, and began to put a more sustained effort into the strength of their own navies. In reaction, the British began in

\textsuperscript{115} Monger, pp. 186-235; Kennedy, \textit{Anglo-German Naval Antagonism}, pp. 275-278; Marder, \textit{Dreadnought to Scapa Flow}, vol. 1, pp. 110-119; Taylor, p. 120.

\textsuperscript{116} Herwig, pp. 58-59.
1889 to put a sustained effort into keeping its navy sufficiently large and sufficiently advanced to stay secure from potential rivals, particularly France.

This effort poured resources into all aspects of naval readiness, including shore installations, trade protection cruisers, and the heart of the navy’s fighting power, its battleships. Battleships formed the core of the fleet, ensured command of the sea, and received the attention that recognized that fact. Between 1889 and 1900 Great Britain commissioned twenty new battleships and had begun construction of 14 others, all of which would be completed by the end of 1902.

However, the expense of this naval buildup, as well as the costs or potential costs of non-naval security issues, pushed Britain to the limits of what political leaders thought the public would be prepared to spend. It became necessary to reduce potential threats diplomatically because the government could not or would not spend the money to be prepared to meet all of them militarily. Great Britain began prioritizing strategic needs, focusing on home defense, trade protection, and defense of the Empire, particularly India, and began the process of accommodation to cut down the number of strategic threats as well as to create possible allies. Relations with the United States rapidly improved after 1895, and the western hemisphere was conceded to American control. The Anglo-Japanese alliance, initially signed in 1902, created a partner to share the burden of defense in the Far East and led to the concession of naval superiority there to Japan. Changes in official attitudes toward France resulted in compromises that reduced the potential threat of France and would eventually lead to a wartime alliance. Shortly thereafter, Russia, in the words of Arthur Marder, “commit[ed] hara-kiri” in the Russo-
Japanese War, and within a few years diplomatic compromises produced an Anglo-Russian *entente*.\(^\text{117}\)

British naval and diplomatic retrenchment, particularly the *entente* with France, has been viewed as a clearing of the decks to focus on the growing German threat. This was a relic of hindsight, and more recent scholarship has reassessed that conclusion. The Royal Navy, at least, while worried about the growth of the Imperial German Navy, remained more concerned with France. Only after the *Dreadnought* had launched were Britain and the Navy convinced that Germany represented its prime potential opponent. From 1906 until World War I the Imperial German Navy remained the only significant strategic concern of the Royal Navy.

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\(^{117}\) Marder. *Anatomy*, p. 435.
Chapter 2:
Setting the Battleship Pattern:
Implicit Thinking and the Guiding Hand of William White

Introduction

When Parliament passed the Naval Defense Act of 1889, its intent was for battleships to be built to ensure that the Royal Navy would maintain naval superiority. The Navy then needed to translate that intent into effective ships. Naval leadership decided that battleships were to be large, armed with the large guns, moderately protected, fast (for their size), and have high endurance. They would be able to move and fight in the open sea in all but the worst weather conditions. The battleships built for the Spencer Program of 1893 served to confirm this as the basic configuration, a configuration that would last all the way to the last battleship built for the Royal Navy in 1951.

This configuration, however, was not a foregone conclusion. Several other options were available, each possessing different size or protection arrangements that would have made battleships very different (and less effective) weapons systems. This chapter examines the process the Navy used to debate what configuration battleships would have. It will show that the Navy had developed a structure to channel this debate, and to make authoritative decisions that were accepted as legitimate throughout the Navy and broader British society. It also finds that while these institutions were not dependent on the abilities of any one individual, a strong-willed individual with clear vision and
strong technical, diplomatic, and communication skills could guide the debate into his (all of the directly involved individuals were male) preferred decisions. Finally, this chapter also finds that while the Navy had a clear idea of its overall strategy—to hold naval superiority in peace and quickly establish command of the sea in war—there was little explicit discussion as to how these goals were to be achieved.

The Naval Defense Act presented the leadership of the Royal Navy with a dilemma. The rapid technological change of the previous half century meant that there was no settled configuration for battleships, and the ensuing debates demonstrated the strength of the Navy’s methods for making decisions. The Board of Admiralty, the Navy’s executive body, held collective responsibility for the Navy’s decisions. More important than its formal authority, though, was its standard practice of consulting other senior naval officers. For instance, First Naval Lord Admiral Hood, the most senior officer on the Board, pressed for a design that would soon be rendered obsolete, and had his opinion alone mattered that would have been the design chosen. Instead, other Board members and senior officers were consulted, and as the balance of opinion was against Hood another configuration was adopted.

Hood was a competent officer, and his assessment of what constituted the best design was, though wrong, reasonable given the information available. However, the practice of consulting widely allowed the Navy to harness the informed opinions of many officers and thereby select a superior battleship design. This formal organization, combined with the informal understanding that the opinions of other important officers would play an important role, came together to create a stronger process and a better
decision. Additionally, the collegial nature of the debate meant that the Navy was able to make decisions without necessarily alienating the losers in the debate. Broad agreement was the goal, so where available, the officers found some middle ground. Admiral Hood acquiesced in the decision not to use his idea; he did not fight to the bitter end. Similarly, one of the new ships was built along the lines he suggested. These kinds of compromises allowed the Navy to spread its bets at the same time it lessened the possibility of creating a pool of disenchanted officers.

The strength of the process, while not dependent on any one individual, was supplemented by the knowledge and ability of one man: William White, Director of Naval Construction. White’s technical ability, his articulateness, and his ability to “manage” the naval officers around him both earned him a role in the exclusive club of decision makers in the navy and allowed him to emerge as the true leader of the process. White led the argument against Hood and in favor of the design that became the Royal Sovereign class. While his ideas must have had support from many officers, he created a viable alternative design and communicated it clearly enough that his ideas held more weight than those of the experienced Hood. He then took the lead in defending the Navy’s decision when the issue emerged into the public sphere, explaining the advantages of the ships as designed and exposing the flaws of alternative proposals. His defense of the Navy’s plans won widespread approval.

The process did have what might have been a significant flaw in other circumstances, but it turned out not to have mattered, at least in the late 1880s and 1890s. Specifically, it did not explicitly articulate the operational role that battleships would use
to achieve the Navy’s strategic goal in war, which was command of the sea. Instead, the discussion skipped down the scale to the size and the basic form a battleship should have. Yet, there is no way to have that discussion without having an idea of operational methods. The operational methods inform, if not dictate, the basic design of the ships—the nature of the job determines the nature of the tools. It is almost impossible not to have a plan for how the ships were to be used to create a design for them. The ideas did exist, but instead of becoming a focal point of the debate on the form and size they were instead implicit in the arguments favoring different basic designs.

There were several reasons this did not become a problem. To begin with, White’s reasoning for backing his designs shows that he had a clear strategic vision of what battleships should do. Failure to define the operational role specifically could have easily allowed imprecise ideas to slip through and create muddled implementation of the design. In addition, White’s vision was congruent with the Navy’s history and culture, which embraced the Navy’s “blue-water” operational legacy, when the Navy operated at sea in all weathers. Officers could and usually did easily think in those terms. Finally, it became clear quickly that the main alternative vision, held by Admiral Hood, was no longer viable, and no other alternative designs really presented themselves for some time.

The concept that battleships were for all-weather open sea operation, as embodied by the Royal Sovereign class, was embraced by the Navy, but the size issue remained. There were several motives for wanting smaller ships. Many were concerned that the large battleship would be vulnerable to a new weapon, the torpedo, and that large ships were obsolete. The cost of large ships and the potential costs (both monetary and in
fighting power) of the loss of a single ship were also concerns. Some officers also valued a larger number of smaller guns over the ability to mount very large guns. Their arguments concluded that a greater number of smaller ships, still configured along the lines of the *Royal Sovereigns*, would be a better use of resources.

Several smaller battleships were built as a result, two as part of the Naval Defense Act program and one more three years later. They were designed with specialized functions in mind which did not require the size or expense of a full sized battleship. In addition, external restraints—namely the failure of the Army-dominated Ordnance establishment, which made the largest guns unavailable—also contributed to the decision to build one of the ships, the *Renown*. The Navy was forced to decide to build a smaller, more limited ship or no ship at all. While it should not come as a surprise that the Navy took something over nothing, it was an expedient that was not repeated.

In 1893, when the Navy won funding for the battleships of the Spencer Program, it once again opted for larger ships. There was still significant support for smaller ships and the debate was renewed. White once again took the lead in defending the decision to build large ships. He was the main spokesman for the Board in its formal defense of its decision to build large ships to the Cabinet, and again articulately defended the advantages of larger ships while skillfully describing the problems with smaller ones. While the officers of the Navy clearly did not unanimously accept the need for larger ships, the case had been made often enough and well enough that significant opposition to larger ships ceased.
The battleship configuration established with the *Royal Sovereign* class was confirmed with the *Majestic* class battleships. This process showed that the Navy had institutionalized a sound decision-making process that harvested the collective wisdom and experience of its officers, by combining a formal administrative body, the Board of Admiralty, with an informal consultation process. The process was also flexible enough to allow an exceptional individual to step forward and reinforce and guide it. The resulting ships filled the Navy’s needs and provided a pattern on which to base future ships.

*The Board of Admiralty and Its Role*

The Board of Admiralty was the apex of the command structure of the Royal Navy and its contact point with the larger British political process. The Lords Commissioners of the Admiralty were collectively charged with the execution of the office of the Lord High Admiral in command of the fleet.¹¹⁸ As a group, they were responsible for the development and execution of naval policy and strategy, within the parameters of national policy set by the Cabinet and Parliament. Members of the Board were also individually responsible for the administration of various support functions, including personnel, material, supplies, and facilities. As a group, then, the Board directed the

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¹¹⁸ For the history of the Board of Admiralty and its creation and functions, see N. A. M. Rodger, *The Admiralty* (Lavanham: Terence Dalton LTD, 1979). R. Vesey Hamilton, *The Administration of the Navy* (London: George Bell and Sons, 1896) is a somewhat laudatory description of the history and functioning of the Board of Admiralty, focusing primarily on the period of the Napoleonic Wars into the 19th century, from the perspective of a former First Naval Lord (1889-1891).
Navy; as individuals, members were department heads charged with efficient administration.

The head of the Board was the First Lord of the Admiralty. Orders in Council in 1869 and 1872 made the First Lord responsible to the Crown and Parliament for the Navy.\footnote{An Order in Council is essentially an executive order issued by the Cabinet as a sub-committee of the Royal Privy Council. In some cases, it must be ratified by Parliament; in others, such as this, it could serve to organize the executive functions of government.} The First Lord was a Member of Parliament and the Cabinet. In theory, he could be a uniformed officer, but that had only happened for one brief period since 1806, and the custom that the First Lord was to be a civilian was well established by the late 19\textsuperscript{th} century.\footnote{Rodger, pp. 69,100-101,107.} As the representative of the civil government, he held executive authority over the Board; all other members were subordinate to him. His position meant that though he was a civilian, he was a recognized part of the “college” that made naval decisions. However, the First Lord was a politician and lacked professional naval experience. Often his primary role on the Board was to represent the interests of the Navy, particularly its budget, to the Cabinet and Parliament; at other times, he was more involved in policy and decision making.\footnote{Rodger, pp. 71-107; Hamilton, pp. 31-48.} The First Lord could impose his views on the Board, but he was ill placed to do so against the unified professional opinion of the naval members without an overriding (usually political) reason. Thus, he both led the Board and was led by it.
The senior naval officer of the Board was the First Naval Lord (changed to First Sea Lord in 1904), the chief advisor to the First Lord and the officer responsible for the efficiency of the fleet. His position was also somewhat equivocal. He was the most important member of the Board after the First Lord, and the senior naval member, with the prestige that it carried. His opinion carried more weight than that of other members, but he could not force the Board in a direction the rest of its membership did not want to go. He also had limited authority over the other individual Board members’ departments, except where they needed direction at the policy level. In many ways, the First Naval Lord was first among equals; in others he was just the most senior officer on the Board.

The other Board members were responsible for specific administrative areas. The Second Naval Lord was in charge of personnel and mobilization. The Third Naval Lord, also known as the Controller, was responsible for the material of the fleet, including ships, guns, engines, machinery, and anything else found on board. The Fourth Lord, also called the Junior Lord, was responsible for supplies and transport. The Civil Lord was a civilian responsible for naval works, which generally meant shore installations and buildings. The Parliamentary and Financial Secretary was responsible for financial oversight. A civilian, he was also a Member of Parliament, a junior minister, and the spokesman for the government on the Navy in the House of Commons, when the First Lord was a member of the House of Lords. Finally, the civilian Permanent Secretary (not an executive member of the Board) managed the correspondence and the Admiralty office. With the exception of the appointment of an additional Civil Lord in 1912, this
was the structure of the Board from the 1870s until 1917. The strains imposed by World War I led to a significant overhaul in the Board’s membership and structure.122

Routine administration dominated the work of the Board. The administrative staff at the Admiralty was very small, and Board members had few or no assistants and little clerical support.123 Despite the administrative demands, the pace of work was not intense in the 1890s, with official hours running from 10 AM to 5 PM but actual working hours closer to 11 am to late afternoon. However, the pace did intensify significantly, and the press of business by the early 20th century demanded much longer hours.124 Under these circumstances, Board members spent most of their time reacting to immediate administrative issues that is, colloquially, plowing through paperwork and putting out fires. The Board’s collective work was little different. It officially met on a weekly basis, though it was uncommon for the full membership of the Board to attend, and minor matters dominated recorded business: retirements, confirmation of court martial findings and penalties, correspondence, and other matters of routine administrivia.125 As this routine administrative work absorbed so much time, there is little indication of active collaboration. Informal conversation must have occurred, though, as their offices were


124 Rodger, *Admiralty*, pp. 116-117;

125 “Board of Admiralty: Minutes and Memoranda,” National Archives: Public Record Office (TNA: PRO) ADM 167 series, especially ADM 167/21 to ADM 167/39 covering the years 1889 to 1905. Special thanks to Dr. Alan Beyerchen for the term administrivia, which captures the spirit of routine administrative matters.
along the same hallway in the same building. However, there were times where individual members might not see each other for weeks, for example when one or more Board members were visiting one of the many Navy facilities outside London, and the press of paperwork tended to keep members tied to their desks.126

Communication between Board members reflected this environment. Memoranda and dockets—collections of memos, responses, supporting documents, and related material—were in constant circulation, and discussed any issue of interest to more than one member of the Board. Information was disseminated, opinions were sought, and approvals given. When appropriate, dockets were circulated outside of the Board to relevant parties. Often this was used to consult other members of the decision making “college”: senior technical experts, admirals in command of fleets, senior ship captains, et al, or to gather relevant information from more junior officers or experts. Given the work hours and amount of other paperwork, and the fact that many of the non-Board members consulted were not in London so the relevant material had to travel by courier, it could take weeks, sometimes months, to arrive at important decisions.127 However, these slow motion “discussions” did do the job of harvesting expertise, collecting opinion, and involving all relevant parties in the decision-making process. It also provided a record of the discussion, one useful not just to historians but also to the


127 Rodger, Admiralty, p. 117.
participants. In an environment where speed was not necessary and collegiality and consensus was at a premium, it was effective.

The Royal Sovereigns: the Debate Begins

As the internal and external concern about the preparedness of the Navy mounted in the summer of 1888, the Board of Admiralty met in August, anticipating that some building program to expand the size of the fleet would emerge from the commotion. Admiral Hood, the First Naval Lord, wanted the new battleships to be similar to the most recent battleships constructed, the *Trafalgar* and the *Nile*, which were laid down in 1886 and launched in 1887.\(^{128}\) The Board decided that the preliminary design should be improved versions of these ships.\(^{129}\) A full meeting of the Board for this type of discussion was unusual, suggesting the importance the Board placed on these ships.\(^{130}\) It was also unusual in its location: Devonport, not the Board’s meeting room at the Admiralty. This move to a remote meeting site took place because the presence of William H. White, the Director of Naval Construction (DNC), was essential. He was recalled from sick leave to attend the meeting and discuss the design options, and would become the most important figure in ship development for the Royal Navy for the next twelve years.

\(^{128}\) To “lay down” a ship is to begin construction. Most ships are launched when the structure is complete, and considerable work, often taking months, is required before the ship is ready to be commissioned and put into service.


\(^{130}\) See “Board Minutes and Memoranda,” TNA: PRO ADM 167 series.
After a period as a dockyard apprentice, Sir William H. White attended the Royal School of Naval Architecture, where he finished his education ranked at the top of his class. He soon became the professional assistant to Chief Constructor Edward J. Reed and Director of Naval Construction Nathanial Barnaby, a position he held from 1872 to 1883, and he also served as Assistant Constructor from 1875 to 1883. White was heavily involved in the design of the Admiral Class ironclads in the early 1880s while working under Barnaby, and during the same period he also taught Naval Architecture at the Royal Schools of Naval Architecture at South Kensington and Greenwich. He presented important papers on ship stability to the Institute of Naval Architects, and authored *A Manual for Naval Architecture* in 1877, which was translated into German, French, Italian, and Russian, and was the standard work in Japan. He briefly left public service to join Armstrong, Mitchell, & Co. as a Warship Designer and Manager of the Warship Building Branch, where he designed a number of well-regarded ships for foreign navies. He was so valued by Armstrong that the Admiralty had to agree to release one of its senior designers, Phillip Watts, who would later succeed White as Director of Naval Construction, to be hired by Armstrong to allow White to terminate his contract and return as Director of Naval Construction in 1885. White began his tenure by reorganizing the Royal Dockyards administration, which greatly speeded construction

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131 Edward Reed was Chief Constructor, the equivalent to Director of Naval Construction, from 1863-1870. Nathanial Barnaby held a number of titles between 1870 and 1885, as the Constructor’s department was reorganized twice. He was effectively Director of Naval Construction 1870-1885, a post he officially held from 1875 to 1885.

times and was instrumental in making them the fastest and cheapest builders of battleships in the world.\textsuperscript{133}

White was and is more widely recognized, though, as one of the foremost intellects of the day involved in ship design. Admirals Sir William H. May and Lord Charles Beresford, both prominent and widely respected naval officers of the time, lauded White as “one of the cleverest designers of ships” and “a man of genius,” respectively, and Beresford credited him for the rapid development of the fighting ship.\textsuperscript{134} White possessed the intellectual ability, the energy and the persuasive powers to make his vision of the battleship the vision of the Royal Navy.\textsuperscript{135}

White submitted the design for the battleships, as directed by Admiral Hood, in the fall of 1888. In order to meet the Board’s requirements for greater speed, larger secondary armament and greater freeboard,\textsuperscript{136} White needed to greatly increase the size

\begin{footnotesize}
\begin{enumerate}
\item Brown, \textit{Naval Construction}, p. 64.
\item See Fredrick Manning, \textit{The Life of Sir William White} London: John Murray, 1923). Manning’s book was commissioned by White’s widow after his death, so it suffers, though not too badly, from obvious biases. One great advantage is that it draws on papers, both official and personal, that no longer exist. See Brown, \textit{Naval Construction}, pp. 51-64 and Brown, \textit{Warrior to Dreadnought}, pp. 123-124 and 219 for commentary on Manning.
\item Freeboard is the height of the upper deck, the first open deck, above the water. A higher freeboard makes the ship less vulnerable to the adverse effects of bad weather and high waves.
\end{enumerate}
\end{footnotesize}
of the ship; the design would displace 16,000 tons (vs. 12,600 tons for the *Trafalgars*) and cost about twenty-five percent more, coming in at about £1 million.\(^{137}\) This was a very substantial increase in weight and cost, especially since the *Trafalgars* were already the heaviest and most costly ships to date for the Royal Navy.\(^{138}\) In addition to the main design directed by the Board, White submitted designs for smaller, less capable ships which like the *Trafalgars* mounted their main guns in turrets, and, apparently at his own initiative, designs for a number of ships with barbette mountings for the main guns.

Oscar Parkes, author of *British Battleships, A History of Design, Construction and Armament, 1860-1950*, the standard reference work on the specifications of British battleships, states that White “pressed the *claims of the barbette*” (emphasis in the original).\(^{139}\) This could mean that White was promoting his own ideas, or that White was acting on behalf of some faction of the Board or a larger group of Naval Officers by presenting alternatives to turret ships. Given that White was not afraid to push his own opinions on ship design, it would seem that he used his position to advance an idea he favored (barbettes), and which he also knew had broad support.

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\(^{137}\) Brown, *Warrior to Dreadnought*, p. 126

\(^{138}\) Roger Chesneeau and Eugene Kolesnick, eds., *Conway’s All the Worlds Fighting Ships, 1860-1905* (London: Conway Maritime Press, 1979), p. 31. The Italian Navy had begun construction of a larger ship two years before the *Trafalgars*, the *Re Umberto* class, which ranked as the largest warships built to that time. See *Conway’s 1860-1905*, p. 342.

\(^{139}\) Parkes, p. 354; Manning, p. 240, also makes this statement, and Parkes is undoubtedly following Manning; Parkes, however, chooses to emphasize the phrase where Manning does not.
Another meeting was held on November 16, 1888, focusing the gun mountings, turrets or barbettes, and the corresponding freeboard. This meeting included not just the Board and White, but also six senior officers: Admirals Dowell, Vesey Hamilton and Richards, who had authored the report on the 1888 naval maneuvers that proclaimed the Navy unready to fight two opponents; Vice-Admiral Baird; Captain Lord Walter Kerr; and Captain John Fisher, the Director of Naval Ordnance. Four of these men would later become First Naval Lords themselves (Hamilton, Richards, Kerr and Fisher), so this was an august group. The consultation of officers not on the Board is an indication of the “college” in practice – formal authority was important, but so was attaining the rank and experience or expertise to be taken seriously and be included in discussions and important decisions.

Other members of the “college” included the Admirals in Command of the various fleets and stations (e.g. the Mediterranean fleet, the Channel Fleet, the China Station). They were consulted and their opinions valued; often they were either recent members of the Board or were likely to become members in the future, or both. Still other “members” were senior officers in other important posts, such as Captain Cyprian Bridge, the Director of Naval Intelligence, or technical experts, like the Captain of the Excellent, the Navy’s gunnery school and experimental station. Other senior officers, particularly ship captains, were men whose opinions were taken seriously and often consulted. These men were the “mind” of the Navy, the body that weighed the relevant information and made the decisions for the Navy.

140 Brown, Warrior to Dreadnought, p. 127.
The primary qualification for admission to this exclusive group was long service, especially at sea. Only Admirals and some highly regarded Captains (and very rarely, if they were sufficiently expert in a technical matter, Commanders) met this criterion. The opinions of more junior officers were not welcome – they were not considered experienced enough to have anything of value to contribute.† Civilians were also generally not considered worthy, though they could be called upon as technical consultants. First Lords were respected out of necessity, though even they were expected to restrain their infringement on what uniformed officers considered matters of professional judgment. White was a rare exception, and was able to move out of the role of consultant to a real decision maker within his area of expertise, namely ship design. He was able to do this both due to his talent and because he gained the confidence of the naval establishment by articulately leading them in their desired direction.

The choice of turrets or barbettes for gun mountings would affect the entire design of the ship. Turrets consisted of large armor casings around the guns, their machinery, and equipment spaces. The entire apparatus functioned as a turntable that pointed the guns. Barbettes were stationary armored citadels that extended down into the ship around the ammunition hoist and working spaces. They were open on top, and the guns and machinery turned independently of them. It is important not to confuse turrets of the 1880s with modern barbette-turrets, which are barbettes with a gun shield resting

† Arthur Marder, *From the Dreadnought to Scapa Flow*, vol.1 (London: Oxford University Press, 1961), p. 11, cites an instance of a Naval Lord, certainly at least a captain and most likely an admiral, noting on a suggestion from a lieutenant, “On what authority does this lieutenant put forth such a proposal?”
on top. These modern barbette-turrets came into use in the mid-1890s and quickly became referred to using the older turret name, causing confusion (see Figures 1-3).

Figure 1. An old style turret (Coles type).

Figure 2. A barbette
The lack of overhead armor and its weight allowed the barbette-mounted guns to be raised much further out of the water without adverse effect on the stability of the ship. This would allow for a higher freeboard, which in turn would allow for a higher speed in poor weather, much more effective firing of the main battery in high seas, and an overall drier ship, as less water would wash over the decks and into various hatches, promoting the comfort (and effectiveness) of the crew. The primary objection to barbettes was that they were significantly less well protected, putting the guns, and part of the crew, in the open. However, most of the crew was under protection, as was the machinery and other equipment.

Admiral Hood was a strong supporter of old style turrets and, as First Naval Lord, was well positioned to press his argument. As rotating armored structures that encased the guns, they offered far greater armor protection to the guns, their machinery, and their
crew. The weight and location of turrets, relatively high up on the ship, precluded a high freeboard, as any further elevation of the weight would make the ship unstable. The low profile of a low freeboard ship was thought to present less of a target to the enemy, which in theory made the ship harder to hit. However, it would be far less seaworthy and more vulnerable to heavy weather. Low freeboard ships could not maintain a high speed in heavy seas, and their guns also had difficulty firing in similar conditions. In addition, despite their lower profile, they were still less stable than a barbette ship.¹⁴² A ship armed with turrets, then, prioritizes protection above seaworthiness.

Andrew Lambert has suggested that Admiral Hood and others favored turret ships because their low profile and greater protection made them superior against forts. Assaults on forts and fortified harbors had become a central element in British naval strategy by 1850. Two issues directed this. First, the Royal Navy had attained such dominance that few enemies would come out to fight, so the Navy, rather than allow the enemy indefinite opportunity to escape or strike at an opportune time, determined it was necessary to be able to go into a fortified harbor and get the enemy. In addition, the ability to attack forts in general was viewed as an important way to project sea power onto land. France’s development a fortified harbor at Cherbourg, on the northern tip of Cotentin Peninsula in Normandy, Lambert contends, caused the British to react by developing equipment and tactics to assault land fortifications. This emerged as an essential part of British naval strategy in the third quarter of the 19th century, making

seaworthiness less valuable relative to other properties of battleships.\textsuperscript{143} He also contends that the British experience during the 19\textsuperscript{th} century, when a large percentage of naval operations were inshore, created a mindset that focused on engaging targets on land, not ships at sea.

This would make for a far more positive interpretation of Admiral Hood than has been common. Hood has been characterized as intensely conservative and disliking all change on principle, and thus as an obstacle to the modernization of the Royal Navy.\textsuperscript{144} Without a doubt, Hood was very conservative. However, while it is clear in hindsight that old style turret ships, which were the standard battleship in the Royal Navy (with the exception of the Admiral class) for over 20 years, were destined to be replaced, it was not yet clear at the time.\textsuperscript{145} Naval and engineering opinion was divided over which type of ship, turret or barbette, was superior.\textsuperscript{146} Hood’s reputation has also been hurt by historian Arthur Marder, who was biased against all officers who were not Admiral Fisher, his followers, or other advocates of changes similar to those espoused by Fisher. Marder characterizes them as backward at best and reactionary at worst, in order to magnify

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\textsuperscript{145} Conway’s \textit{1860-1905}, pp. 20-31.

\textsuperscript{146} Brown \textit{Warrior to Dreadnought}, p. 127.
\end{flushleft}
Fisher’s genius. Hood, who with many others also initially opposed the naval build up in the 1880s, was not a progressive in the Fisher mold.\footnote{147}

Lambert contends that Hood envisioned a specific strategic purpose envisioned for turret ships, and shows Hood not to be an unthinking reactionary, but rather an advocate of a ship type that was compatible with an operational plan. Hood may have been unable or unwilling to see a slowly growing body of evidence that attacks on forts were not practical under conditions that existed by the end of the 1880s, but the evidence was not yet decisive. Nor was Hood alone, as other officers agreed with him. While ultimately proven wrong, the plan was reasonable and the ship type Hood advocated was adapted to it.\footnote{148}

White favored high freeboard ships because he thought the higher position of the main guns, with the consequent superior speed and ability to fire the guns in poor weather, was better, and he went to work to win the debate.\footnote{149} To win, White needed to convince the Board that a barbette design could be sufficiently protected, and that a high freeboard was needed to allow the ships to move at high speed and fight in all weather. White’s barbette design improved the protection of the ammunition hoists, shell rooms, and loading rooms of barbette ships by developing armored citadels around them that went well below the water line.\footnote{150} This partially offset the protection advantage enjoyed

\footnote{147}Marder, Anatomy, pp. 125-126.

\footnote{148}Andrew Lambert, “The Royal Navy, 1856-1914.”

\footnote{149}Manning, pp. 239-241.

\footnote{150}Parkes. p. 358.
by turret ships. White also cited experience with the low freeboard *Admirals*, which were known as wet ships that had difficulty with high seas, as demonstrating the need for higher freeboard on the new ships.\(^{151}\)

This was essentially a debate about what battleships of the fleet were used for, that is, about which operational methods would be used to pursue strategy. The point illustrates the dynamics of how strategy and methods affect equipment. There was no explicit discussion of strategy involved in making the design decisions, and no process that decided what role the ships were to play or what operational methods they would use. It was assumed that battleships would provide command of the sea, either by defeating or blockading the enemy (most likely, the French), but there was no explicit discussion of how this would be done.

The development of the French naval base at Cherbourg, along with other British naval operations of the 19\(^{\text{th}}\) century, prompted a response in British thinking that envisioned a descent on the port, to eliminate it as a base for the French Navy. This strategy helped lead to decisions on the nature of battleships that emphasized low profile, heavily armored ships thought to be most capable of carrying out the mission, which was to fight their way past coastal forts to get at French ships and port facilities. Others envisioned that the fleet would need to fight and maneuver on the open seas. Battleships would need to be seaworthy to stand blockade duty, and to confront the French (or Russian) fleet and defeat it in battle should it attempt to leave port. This line of thinking emphasized the need for seaworthiness and a less armored ship with a higher freeboard.

\(^{151}\) Ships Cover Number 120, *Royal Sovereign* Class, NMM.
While certain naval officers, mostly in other contexts, made explicit arguments about how battleships were to be used, it does not appear that White ever articulated the reasoning for high freeboard barbette ships this way. Yet he clearly thought in terms of the open sea method, as his arguments about the proper design of ships meshed perfectly with the needs of ships that would be used that way.

Ultimately, the Board and the other officers present at the meeting, save Admiral Hood, sided with White and chose a barbette design for the bulk of the new vessels. They agreed with White that the barbettes’ superior ability to operate and fight in poor weather outweighed the greater protection offered by old style turrets. In deference to the First Naval Lord, however, one of the eight new first class battleships was to be a turret ship, and it was named Hood in the First Sea Lord’s honor—or to attach any opprobrium for its failure firmly on its one backer on the Board, depending on the point of view of the analyst. Given Hood’s strong support of turrets and the broader support

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152 See Marder, Anatomy, pp. 66-74, for the development of the “blue water” school of naval defense. While this school was concerned more specifically with the debate on naval vs. military defense of Britain, the “blue water” school articulated the idea that the role of the fleet, and thus the battleship as the focal point of the fleet, was to dominate the high seas. Andrew Lambert, The Foundations of Naval History, John Knox Laughton, the Royal Navy, and the Historical Profession (London: Chatham Publishing, 1998), pp. 106-113, also discusses the writings and thought of prominent naval thinkers, including senior officers such as Phillip Colombe, Geoffrey Phipps Hornby, Ashley Cooper Key, Cyprian Bridge and Regenald Custance, who were highly respected and leaders in developing explicit thought about strategy.

153 Ships Cover No. 120, Royal Sovereign class, NMM.

154 Manning, pp. 242-243.

they had within the navy, the near unanimity of the Board in favoring the barbette design was a tribute to White’s persuasive ability. It was also a victory for the idea of the battleship as a weapons system that operated in the open seas.

The allotment of one of the Royal Navy’s brand new vessels for a design that was not generally favored was a compromise typical of this period. “Winners” did not insist on total victory; instead, some accommodation was reached so that both sides of a debate were rewarded. It also brought “losers” on board by giving them something, which included them and fostered their support of the process. Furthermore, it kept animosity to a minimum, which was important in an organization that required a high level of cohesion to fulfill its mission. In addition, it showed a basic element of respect for the opinions of a fellow officer whose long service and demonstrated competence proved that whether he was right or wrong on any particular point, his opinion was well grounded in the reality of the service and was worthy of being taken seriously. Finally, while it meant that the “best” choice was not universally used, it did mean that the Royal Navy had a diversity of different equipment, which allowed experience with alternatives. This permitted quicker adaptation to a readily available alternative, if needed. Remember, too, that during a period of rapid change (which the Royal Navy was in the middle of) judgments as to what constitutes the “best” can be wrong. The “hedging” of bets on major decisions is sound insurance against devoting everything to the wrong answer that

looks right at the time.\textsuperscript{156} This is yet another way of harvesting collected wisdom and making it available to the Navy.

\textit{The Debate goes (Semi) Public}

While the Admiralty was finalizing the details of the design, public criticism of the ships began. It was a limited public, consisting of those with specialized interest or knowledge of naval vessels and more than general knowledge of naval warfare. This public presented their opinions in forums that were attended or read by fellow experts: naval architects, marine engineers, and naval and military officers. There were two primary complaints: the ships were far too large (and expensive), and their armor coverage was grossly deficient. Former Directors of Naval Construction Edward J. Reed and Nathanial Barnaby, White’s two immediate predecessors, led the public attacks on the ships, and they were joined by some naval engineers, amateur naval strategists, and a few naval officers. This debate, like the one of barbettes verses turrets, was ultimately about what kind of battleships the Navy needed.

The greatest concern was the size of the ships. At 14,000+ tons, the \textit{Royal Sovereigns} were substantially larger than any other warship, and they bore a

commensurate cost: about £978,000, including armament.\textsuperscript{157} All of the designs to which the Board gave serious consideration were in that size range, but many civilians and some naval officers thought that such a large size was a mistake. The argument revolved around the claim that a large ship was putting all of the Fleet’s “eggs” in one basket. Since such large ships were so expensive, only relatively few could be built. As such, the loss of one ship would not only be a severe financial setback, it would also entail the loss of a significant percentage of the Fleet’s fighting power.\textsuperscript{158}

The torpedo, or automotive torpedo as it was known at the time, was the weapon driving that worry. While the development of the torpedo is beyond the scope of this project, it is necessary briefly to review its status as a weapon in 1889. Robert Whitehead, a British engineer living in Fiume, Austria, built the first functioning self-propelled torpedo in 1866. Improvements in speed and accuracy were rapid, and most major navies had adopted some form of them by the 1870s. By 1889, the best models

\textsuperscript{157} Manning, p. 295. In a memo for the Cabinet, “The Characteristics and Dimensions of Battleships,” minute to the Cabinet by William White, printed December 13, 1895, in TNA:PRO CAB 1/2/14, White cites a costs of £980,000 and £987,000. Parkes, pp. 355, 364, lists costs ranging from £912,000 to £980,000, including armament, depending on the individual ship. Brown, \textit{Warrior to Dreadnought}, p. 218, cites a cost of £864,000, exclusive of armament, from an audit of the costs of ships from the Naval Defense Act. Jon Sumida, \textit{In Defense of Naval Supremacy: Finance, Technology and British Naval Policy, 1889-1914} (Boston: Unwin Hyman, 1989), Table 16, lists an average cost of £923,023 for the eight ships (including \textit{Hood}). The range is largely the result of the limits of the accounting procedures used at that time.

had a range of up to 1,000 yards at 22 knots and carried an explosive charge of over 78 pounds of wet gun cotton, an explosive similar to smokeless gun propellants.\textsuperscript{159}

Naval thinkers had developed great respect for the potential efficacy of the torpedo, especially at night or in narrow waters, which restricted maneuvering, such as in harbor.\textsuperscript{160} By the time of the Naval Defense Act, torpedoes had sufficient range and explosive power to be a danger to a battleship even without stealth or surprise. Gunnery doctrine called for ranges in the hundreds or at most a couple of thousand yards, and naval battles were expected to be confused melees.\textsuperscript{161} Most expected torpedoes to be very effective weapons, and the large majority of battleships were either designed with torpedo tubes (as the \textit{Royal Sovereigns} were) or were retrofitted with them.\textsuperscript{162}

More importantly, small, fast ships were being purpose built as torpedo platforms. Their size, speed, and agility made these ships difficult targets, especially for the large main guns of battleships, which were time consuming to aim and had a very slow rate of fire (some were as slow as two minutes per shot). This would allow torpedo boats to close quickly within torpedo range of the larger, slower, less agile battleships and

\begin{itemize}
  \item \textsuperscript{160} Cowpe, pp. 27-36; Marder, \textit{Anatomy}, pp. 123-124.
  \item \textsuperscript{161} Marder, \textit{Anatomy}, p. 123.
  \item \textsuperscript{162} See Parkes, pp. 216-370, or \textit{Conway’s, 1860-1905}, pp. 17-33, for torpedo armament from the \textit{Alexandra} class through \textit{Centurion} class, 1877-1894.
\end{itemize}
effectively bring their weapons to bear. Torpedo boats were also extremely inexpensive compared to a battleship. This made them seem a cost effective alternative to battleships, and many thought they had made battleships obsolete.\textsuperscript{163}

A secondary argument made in favor of smaller ships was that it was important to maximize the number of guns for the fleet, even if these guns were not the largest available and unable to pierce heavy armor. This argument derived from the idea that most ships, even the ones with very thick armor, had large unarmored areas, particularly the superstructure above the main deck. The idea was to riddle these vulnerable parts of the ship with quick-firing guns. The ultimate manifestation of this idea was the “swarm” of ships model, where large numbers of smaller ships would overwhelm a large ship, which could not respond to them all with its relatively small number of larger, slow-firing guns.\textsuperscript{164}

Advocates for larger ships, which included the Admiralty, most British naval officers, and most of the political establishment, were not convinced. While admitting the torpedo was dangerous, they did not see that it had made large ships so vulnerable to attacks by torpedo-armed smaller vessels that they were no longer viable weapons.


\textsuperscript{164} Manning, pp. 295-297.
Larger ships had speed, endurance, protection and firepower integrated in ways that small ships could not match. The offensive capabilities of larger ships were most favored, as they could carry very large guns, capable of piercing heavy armor. Along with this, many naval thinkers concentrated on the idea of the “knockout blow,” that is, a hit on a critical system such as the engines or magazine that would eliminate the ship as a fighting force. Such systems were under the heaviest protection, and only heavy guns could hope to pierce such armor. In addition to being able to carry the heaviest guns, a large ship could support a larger secondary armament. This secondary armament, especially if they were quick firing (QF) guns, made a very effective torpedo boat defense, partially countering that threat, and could effectively tear into the unarmored portions of the ship – that is, a large ship could do the job of the lightly armed small ships and have heavy guns, too.\footnote{Marder, \textit{Anatomy}, pp. 124-125.}

A larger ship was also the embodiment of concentrated firepower in a way that a collection of smaller ships could not match. One ship, with a single crew and captain, was far easier to control and direct under battle conditions than separate ships would be.\footnote{See Luttwak, pp. 33-38, for a discussion of the relative merits of small, cheap and specialized verses large, expensive, and general ships.} Unlike most of the arguments, this was not an issue of hardware, but instead related to non-technical, command and control issues: the Royal Navy was well aware of the limitations of multiple ship coordination and control in battle. It was also an area on

\footnote{As White was careful to note in “The Characteristics and Dimensions of Battleships,” TNA: PRO CAB 1/2/14.}
which the Navy focused considerable improvement efforts, as will be discussed later.\textsuperscript{168}

In addition, larger ships were a steadier gun platform. They were more stable in light seas, and had longer periods of movement in heavier seas.\textsuperscript{169} A larger ship could also carry more substantial armor. This, combined with its size, made it less likely to be effectively eliminated as a combat unit by a single shot from an enemy ship since it could both fire and absorb blows from very heavy guns. In addition, only a large hull could carry the machinery—the boilers to generate sufficient steam and the engines to provide enough power to turn the shafts and screws hard enough—needed to generate high speed for a ship carrying large guns and significant armor, a tactical and strategic advantage.

In addition, many noted that the \textit{Royal Sovereigns} were at least the equals of the newer French ships which had just been launched or were under construction. It was a point of pride that the Royal Navy, in White’s words, “did not build ships that were known to be inferior [to] likely opponents.”\textsuperscript{170} In this, White is echoing the 1871 Committee on Designs, which stated, “our own fleet shall be more than equal, both in number and power of its ships.”\textsuperscript{171} This point shows the mentality of both the Royal Navy and the public, including the elite public and masses. It is an attitude that says we

\begin{footnotes}
\item[170] Manning, pp. 295-297.
\item[171] “The Characteristics and Dimensions of Battleships,” minute to the Cabinet by William White, printed December 13, 1895, TNA: PRO CAB 1/2/14.
\end{footnotes}
expect nothing less than the best, and we do not settle for less. It also shows something of the political and elite public it was aimed at: that it shared the attitude and would accept the argument without question.\textsuperscript{172} In the environment prevalent at the time, it was an effective rhetorical device. It is also completely irrelevant to the issue. No important voice advocated an inferior fleet. The advocates of smaller ships were claiming that a large number of small ships made a better fighting fleet than a small number of larger individually more capable ships.

The debate reached a climax in the spring of 1889, after the passage of the Naval Defense Act. At the meeting of the Institute of Naval Architects in April of 1889, White gave a paper explaining and justifying the design of the \textit{Royal Sovereigns}. The Institute was a body of naval designers, engineers, industrialists, and naval officers with an interest in and expertise in shipbuilding, both naval and civilian. They met yearly, sometimes twice yearly, and various members (or occasionally guests) gave papers on various aspects—usually technical—of ship design, equipment or construction, and the papers were then discussed. It was a very typical Victorian era professional society, and an important forum for the interchange of ideas as well as a collegial group of individuals with similar knowledge and interest.\textsuperscript{173} The Institute both spread and critiqued ideas,

\textsuperscript{172} Marder, \textit{Anatomy}, pp. 44-81, provides a summary of British attitudes, and their evolution, in the 1880s and 1890s.

which made it an important body for the development and spread of innovation.\footnote{174}{See the \textit{Transactions of the Institute of Naval Architects}, vol. 1 – vol. 101, 1860-1959, (when it became the Royal Institute of Naval Architects).}

White’s appearance at the Institute to read a paper, setting out the reasoning behind his design decisions and the Board’s adoption of them, shows how important it was in the field.

Edward Reed, the former DNC, responded to White’s paper with a very detailed and articulate attack on the ships in general and White’s armor system in particular. The discussion that followed, however, vindicated White. He set out a point by point refutation of Reed’s criticism. For example, Reed was very critical of the unarmored ends of both the \textit{Royal Sovereigns} and the \textit{Admirals}, a design in which White, as Assistant DNC, was heavily involved, on the grounds that flooding caused by battle damage would badly undermine the stability and maneuverability of the ships. This was a powerful argument, until White announced that the forward hull of one of the \textit{Admirals} had been flooded as a test, and the flood had only a small effect on stability or maneuverability.\footnote{175}{William White, “On the Designs for the New Battleships,” \textit{Trans. INA}, vol. XXX, 1889, p. 213.} Further discussion ensued, as many of those present wished to make their views known, but in general the discussion was heavily favorable to White.\footnote{176}{William White, “On the Designs for the New Battleships,” discussion of the paper by the assembled membership, \textit{Trans. INA}, pp. 180-215.}

Following the discussion of White’s paper, Nathanial Barnaby, also a former DNC, gave a paper in which he advocated the construction of very small, 3,200 ton ships.
These ships would be provided with reserve flotation by the addition of special, lightweight materials packed into various compartments (which was also to perform as secondary armor protection), and equipped with relatively small guns and coal supplies. Barnaby contended that up to five of these ships could be produced for the cost of one Royal Sovereign. This would be a far better value for the Navy, he argued, and minimize the cost of losing a ship.\footnote{Nathanial Barnaby, “The Protection of Buoyancy and Stability in Ships,” \textit{Trans INA}, vol. XXX, 1889, pp. 216-226.} The ensuing discussion included both Barnaby’s ideas and topics from the earlier discussion about White’s paper and Reed’s response. Here again the general discussion favored White’s designs. Most of the support for Reed and Barnaby came from other naval engineers, but few of the naval members present supported either Reed or Barnaby. An exception was Admiral Geoffrey Phipps Hornby, perhaps the most highly regarded admiral of the time, who spoke in favor of Barnaby’s design ideas.\footnote{William White, “On the Designs for the New Battleships,” and Nathanial Barnaby, “The Protection of Buoyancy and Stability in Ships,” \textit{Trans INA}, vol. XXX, 1889, discussion of the papers by the assembled membership, pp. 180-215, 227-243.}

Ships configured as Reed or Barnaby advocated would have functioned very differently than the \textit{Royal Sovereigns}. Armor coverage as extensive as Reed envisioned would have made the ship a great deal heavier and thus much slower and probably lower riding in the water. Such a ship would have looked similar to Hood’s idea of the ideal battleship and be well suited for inshore work. The relatively tiny ships advocated by Barnaby would have been little more than lightly armed mobile coastal forts, suited for
coast defense but little else. In either case, the ships could not have played the high seas role envisioned for the *Royal Sovereigns*.

White’s thoughtful and articulate defense of large battleships’ moderate protection and seaworthiness—in other words, the barbette centered design of the *Royal Sovereigns*—combined with strong doubts within the Royal Navy about the efficacy of torpedoes, carried the argument decisively.\(^{179}\) Critics of the Admiralty’s ship designs remained, of course, and only a few, most notably Reed, were converted.\(^{180}\) The debate about the efficacy of large battleships versus moderate or smaller ones did not end, but large battleships became the established standard. It was a decisive victory for White, the Board, and the vision of a seagoing, long ranged, balanced heavy ship.

Further support for the effectiveness of White’s design came later, in the Sino-Japanese War. Two Chinese ships (built by British shipbuilders) which, like the *Royal Sovereigns* had unprotected extremes fore and aft, were pounded by the Japanese at the battle of Yalu in 1894. Both ships suffered heavy damage to their unprotected bows and sterns yet they were both still seaworthy after the battle.\(^ {181}\)

While the most vocal critics were calling for more armor, there were others who complained that there was too much. Admirals Cyprian Bridge and Reginald Custance both thought offensive capabilities were being sacrificed to provide protection, and Bridge claimed that many young captains agreed with him. Firepower and the offensive

\(^{179}\) Cowpe, pp. 30-34.

\(^{180}\) Brown, *Naval Construction*, p. 66.

\(^{181}\) Parkes, pp. 190-191; Marder, *Anatomy*, p. 137.
were what mattered—naval battles were won by inflicting catastrophic damage on one’s enemy, not timidly avoiding any damage of your own.  

Both men typified the “old school” Navy, where good seamanship and good character counted for everything. Historically, in the days of the sailing navy, the British were successful in naval battles by closing with opponents and using its crews’ superior training and morale, which translated into relatively high rates of fire, to batter opponents into submission. A British ship would endure damage as the price paid for victory. Bridge also complained that new ships were growing ever more complicated for no purpose. He did not seem to grasp that changes in technology meant modifications in naval equipment, which demanded changes in how those ships fought. This also indicated he was not very good at assessing what new equipment was most useful and needed, nor how to fit it all together. Ironically, both men were vicious opponents of battlecruisers when Admiral Fisher introduced them. Yet, battlecruisers were very similar in principle to those ships Bridge and Custance espoused: relatively heavy on firepower and very light on armor. (Of course, they were also supposed to fight from long range, not close up.) Neither Bridge nor Custance made their cases in a public forum but rather within the closed circle of fellow officers. The Board of Admiralty and

182 Letter from Bridge to Custance, August 14, 1891, BRI 18/4; Letter from Bridge to Custance, January 21, 1892, BRI 14/4; Letter from Custance to Bridge, June 3, 1902, BRI 15/2; NMM.
other officers directly involved in decisions might reach consensus, but that was no guarantee that the whole “college” would be in unanimous agreement.\textsuperscript{183}

As noted, dissension to the Admiralty’s decisions on the type of battleship to build was public, but the participants were a limited, specialized, public. Critics were trying to sway the opinions of fellow experts so that they would exert pressure on the Admiralty to change its positions. If enough important naval officers could be convinced that the \textit{Royal Sovereigns} were a poor design, the Board of Admiralty, conscious of the fact that it represented a broader number of “college” officers, could be made to adapt to the larger consensus.

Alternatively, critics hoped to sway enough opinion that the government might be influenced to intervene. This was rare, but it did happen. The most famous case was the construction of the \textit{HMS Captain}. After his service in the Crimean War (1853-1856), Captain Cowper Coles developed a gun turret similar to the one mounted on the \textit{U.S.S. Monitor} of the American Civil War. The turret concept was well received by the Admiralty, but Coles was unhappy with its implementation on British ships. Coles wanted the Admiralty to build a ship to his specifications, but it refused to do so. Political pressure was brought on the Government, which eventually authorized Coles to have the ship, the \textit{HMS Captain}, designed and built privately in 1866. However, the result was a disaster. Partly due to its design and partly due to errors made during its construction, the ship was only marginally stable, and it capsized in a gale on its maiden

\textsuperscript{183}Letter from Bridge to Custance, January 21, 1892, BRI 14/4; Letter from Custance to Bridge, June 3, 1902, BRI 15/2, NMM.
voyage in July 1870, with the loss of 417 officers and men, including Captain Coles. While the Admiralty was not entirely blameless, the design was far less seaworthy than others approved of by the Admiralty (and disapproved of by Coles) around that time. The Captain served as a warning to both officers and politicians of the dangers of overruling the professional judgment of the Board.\textsuperscript{184}

\textit{A Small Battleship Detour}

Two of the ships built for the Naval Defense Act of 1889, the second-class battleships Centurion and Barfleur, seem to contradict this narrative. They were what the name implied: smaller, cheaper and less capable versions of full size battleships: diminutive Royal Sovereigns, displacing 10,500 tons vs. 14,150 for the Royal Sovereigns.\textsuperscript{185} While not as tiny as the ships Barnaby was advocating, they did not fit the mold established by the Royal Sovereigns. However, their projected role was different than those envisioned for the Royal Sovereigns or the Hood. Their function was to serve where it was thought that full size battleships were not needed. Specifically, these ships were designed for use at the China and Pacific Stations, where their most likely main opposition would have been Russian cruisers, not battleships. In addition, their smaller size and shallower draft meant they had some operational capability in Chinese rivers. Both served in China, in the Mediterranean, and in reserve.

\textsuperscript{184} See Rodger, pp. 110-111 and Brown, \textit{Warrior to Dreadnought}, pp. 41-54 for accounts of the building of the Captain and its flaws; for an account more sympathetic to Coles and critical of the Admiralty, see Parkes, pp. 126-143.

\textsuperscript{185} Parkes, pp. 355, 366.
This is another example of implicit strategic thinking at work. Battleships established command of the sea by virtue of being the most powerful ships available. The naval situation in Asia was such that the *Centurion* and *Barfleur* were expected to be able to establish command without being as large or powerful as the ships required to fulfill the same role in European waters. The recognition of the different conditions under which the *Centurion* and *Barfleur* would serve was followed by the recognition that the ships could be different. As smaller and faster ships they could conceivably fill other roles as well—power projection ashore and, potentially, trade protection. In addition, their small size allowed them to traverse the Suez Canal and thus reinforce the fleet in Asia significantly more quickly. All these were important points of utility that offset the advantages of the battleships’ large size: heavier armament, thicker armor, greater endurance, superior handling in heavy weather, and concentrated power.

White had a different idea of where to obtain the less powerful ships to fill the role envisioned for second class ships. He thought that the pace of ship improvement was such that first-class ships could be expected to be inferior to the newest ships before they were in need of replacement. These ships, he contended, should be used for second-class roles. For White, the only worthwhile use of limited construction funds was full size ships, so that Britain did not build ships inferior to those of an opponent.¹⁸⁶ This time, unlike in the old turret vs. barbette debate, leading naval officers did not agree. They wanted new ships.

¹⁸⁶ “The Characteristics and Dimensions of Battleships,” TNA: PRO CAB 1/2/14. The use of older ships for second class roles was common.
Full size battleships could still have been built—since they offered the flexibility to be deployed anywhere against any potential enemy—but one final liability to the large battleship intervened: cost. Whereas those who advocated small battleships for operational reasons lost the debate on main fleet units, those who advocated smaller battleships to manage the budget were successful. Despite Parliament’s record of spending on the Navy when it perceived British naval supremacy threatened, fiscal policy and political necessity kept spending and taxes very low by modern standards.\(^{187}\) Budgetary considerations were powerful, as Boards were always concerned with costs.

This applied not only to the First Lord, who was a politician and responsible for naval budgetary demands to the Cabinet and defending them before Parliament, but also to the naval members of the Board. The Admiralty could count on money when really necessary, or perhaps more accurately, when the Cabinet and Parliament thought it really necessary. If, however, there was no emergency or perception of threat, the funding for the Navy was limited by the general frugality of the British Government and Parliament. With that in mind, the Board knew it had to balance its desires to have everything it wanted with its ability to get it paid for.\(^{188}\) All discussions about ship designs concerned, to a greater or lesser degree, the cost of the ships—and all else being equal, cheaper was better. This, of course, did not prevent the Admiralty from asking for money, if it thought money was needed, because all else was rarely equal.


\(^{188}\) Hamilton, pp. 166-168.
In the case of the Centurion and Barfleur, the second-class battleships of the Naval Defense Act, it was possible to save money and still get new ships that had the desired capabilities. However, these ships (and the Renown, discussed later) were just a detour. In the long term, the increasing size and power of the French, Russian, and Japanese fleets in the Far East created a situation where second class battleships were no longer sufficient to establish British naval superiority. In addition, the growth of the number of large battleships in foreign navies became the compelling strategic issue for the Royal Navy. Thus, the intersection of a particular strategic need and the desire to save money created second class ships; the evaporation of that need and the growth of other priorities made the construction of second class ships a detour in the development of battleships for Britain.

The Majestic Class: Delays to Further Building

Concern with the state of the Navy did not end with the building of the Naval Defense Act ships. The French continued to announce large new naval construction programs. As was often the case, the French government was unable to maintain the pace of building it had set for itself, but it took a number of years for this to become apparent. Meanwhile, the Russian Navy received large appropriations for construction, which combined with the perceived vulnerability of the Turkish straits and the Franco-Russian alliance caused the British to become greatly concerned with their position in the
Mediterranean. In the spring of 1892, the Board approved a program for seven new battleships: three in 1892-93, followed by two more in 1893-94 and two more later.\textsuperscript{189}

Political approval and funding seemed likely to follow. However, a Liberal government under Prime Minister Gladstone, who was opposed to large military expenditure, came to power in August of 1892. It did not approve of the additional ships, and allowed for only the first three ships of the program, which had already been approved by the previous government. A year later, in the fall of 1893, the political situation changed rapidly. Worries about France and Russia resulted in a naval scare that peaked then. The Board, led by new First Naval Lord Admiral Richards, proposed a plan for seven new battleships to meet the perceived threat. After tumultuous political debate, including the resignation of Prime Minister Gladstone, (who steadfastly opposed the increase in naval spending), the cabinet approved a new program of construction. It included seven new ships beyond the already begun \textit{Renown} and the shortly to be commenced \textit{Majestic} and \textit{Magnificent}. The Spencer Program, named after First Lord Earl Spencer, who had been pivotal in gathering Liberal support for it, was passed a short time later, in December 1893.\textsuperscript{190}

While this political maneuvering was in process, the Navy encountered other problems. It had begun initial planning for the building program in 1891, the year before it was agreed upon by the Board. Captain Compton Domville, Fisher’s successor as Director of Naval Ordnance (DNO), submitted a written proposal to the Board in April

\textsuperscript{189} Marder, \textit{Anatomy}, pp. 155-169.

\textsuperscript{190} Marder, \textit{Anatomy}, pp.170-205.
1891 that a new design for new 10 and 12 inch guns should be requested from the War Office, in anticipation of needing them for the next class of battleships to be built after the completion of the Royal Sovereigns. The Board agreed, and submitted the written request to the War Office in May. In July, a War Office memo agreed to begin work.\textsuperscript{191}

Despite this agreement, a combination of War Office indifference and bureaucratic evasion meant that nothing had advanced by December 1891. An inquiry by Captain Domville initially received only an evasive response. Only when he threatened to order the guns from private firms did the Director of Artillery respond, and then he blamed the Ordnance Committee (dominated by the War Office) for not approving a design. The DNO told the War Office that the Navy was prepared to forget the Ordnance Committee, and proceed to order the gun on its own authority. If the trial gun was acceptable, then the Navy would place an order for more.\textsuperscript{192}

The threat appeared to work, for in February 1892 the Director-General of Ordnance Factories submitted a design for a 40 caliber gun to the DNO’s office.\textsuperscript{193} A

\textsuperscript{191} “Précis of Correspondence Relating to the Introduction of new design 12-inch B.L. Wire Gun: delays caused by War Office,” from “The Monthly Record of the Principal Questions Dealt with by the Director of Naval Ordnance,” July-December, 1892, TNA: PRO ADM 256/28.

\textsuperscript{192} “Précis of Correspondence with War Office,” July-December, 1892, TNA: PRO ADM 256/28.

\textsuperscript{193} Caliber in this context is the length of the gun bore (the inside tube of the gun) in multiples of the bore diameter. A 20-caliber gun would thus have a bore length 20 times its diameter.
design for a 35 caliber gun followed in March. The 35 caliber gun was approved immediately, due to concerns that the 40 caliber design was too long. The plans were submitted to the Ordnance Committee in April of 1892, which recommended a few small changes. Domville requested that the design be reviewed in a conference with private gun manufacturers, which added a significant delay as the conference was not scheduled until June, when the design was finally approved by all consulted. However, the delay served its purpose: the Ordnance Factory received an order for six and the private sector received orders for four, splitting the work. The War Office was put on notice that it would be bypassed if its work was unacceptable, and the armaments firms were given business that helped prime them for future work. Work on the guns began in August 1892, with the first gun scheduled to be completed and ready for proof tests in about one year.

This process illustrates the difficulties the Navy encountered when dealing with the War Office for ordnance. The War Office was famously incompetent, even more bureaucratic than the Navy, and unwilling to modernize and adapt. An organization that had lost a regiment in England in peacetime in 1886, and was completely unprepared for

194 “Précis of Correspondence with War Office,” July-December, 1892, TNA: PRO ADM 256/28.

195 “Memoranda Respecting design of 12-inch B.L. Wire Gun—Length of future Guns,” and “Memoranda regarding 12-inch B.L. Wire Guns – Size of Chamber,” circulated to the Board of Admiralty, and within the Controller’s Office, from “The Monthly Record of the Principal Questions Dealt with by the Director of Naval Ordnance,” 1894, TNA:PRO ADM 256/30

196 “Précis of Correspondence with War Office,” July-December, 1892, TNA: PRO ADM 256/28.
the Boer War, could hardly have been expected to meet the Navy’s needs when it could not meet its own.\textsuperscript{197} While there was no active hostility, nothing moved quickly and naval needs were not pursued diligently unless someone from the Navy, usually the DNO as in this case, actively pushed the War Office along. In addition, communication back and forth could be slow and occasionally imprecise, providing more delays and giving opportunity to deflect blame for lack of progress.\textsuperscript{198} The Navy knew what it needed and attempted to have it ready in time. It was let down by its sister service.

The Navy’s slow pace of work, lack of intensity, and absence of support staff for officers with administrative responsibilities undoubtedly also contributed to the delay. Captain Domville failed to follow-up with the War Office for about five months. He was very likely busy with other issues, and since he had the assurances that the guns would be made he did not pursue the issue diligently—something that a member of his staff, had he had one, could have done. However, despite Domville’s failure to follow-up vigorously, the fault was still with the Army for not fulfilling its commitment.

\textsuperscript{197} Edward Spiers, \textit{The Late Victorian Army, 1868-1902}, (Manchester: Manchester University Press; dist. New York: St. Martin’s Press, 1992), provides a good overall summary of the state of the Army in the late 19\textsuperscript{th} century, with emphasis on significant constraints on the Army during the period and the political difficulties instituting needed reforms; see also Edward Spiers, \textit{Haldane: An Army Reformer} (Edinburgh: Edinburgh University Press, 1990), especially the chapters “Reform of the Regular Army,” “The Territorial and Reserve Forces Act” and Creating and Imperial General Staff,” which outlines the state of the Army before Haldane’s reforms as Secretary of State for War beginning in 1905; see Rodger, \textit{Admiralty}, p. 115 for the story of the mislaid regiment.

\textsuperscript{198} For example, see “Précis of Correspondence with War Office,” July-December, 1892, TNA: PRO ADM 256/28.
The delay of the new 12” gun represented a problem for the Navy. The guns would likely not be ready for the ships if they were begun, as tentatively planned, in late 1892 or early 1893. Small ship advocates, including Fisher, now a Rear Admiral and Controller who was at this time in his career advocating “the lightest big gun and biggest secondary gun,” persuaded the Board that construction of a small battleship, armed with the 10-inch gun, was better than allowing the Pembroke dockyard to be idle. The Renown, the last second-class battleship built for the Royal Navy, was then laid in February 1893. In the meantime, construction on the other two ships, the Majestic and Magnificent, was delayed by one year. Small ship advocates had a victory.

The Size Debate Renews

The planning for the Majestic and Magnificent kindled the resurgence of the debate over the size of battleships that had raged around the Royal Sovereigns. The arguments developed along the same lines as before: very large ships were too vulnerable and not

199 Parkes, p. 370.

200 Two others, the Swiftsure and Triumph, were purchased from Chile (for whom they were built) in late 1903, to prevent their sale to Russia. This was a diplomatic favor to British ally Japan, which was experiencing increased tension with Russia. See Ian Nish, *The Anglo-Japanese Alliance*, (London: The Athlone Press, 1966), pp. 270-273, for details on the purchase. Parkes assesses the Swiftsure and Triumph as powerful second-class ships, but while Conway’s classifies them as second-class battleships, it notes that they were only suitable for use against older cruisers. Brown also compares them to cruisers, and neglects to list them with the pre-dreadnought battleship classes. See Parkes pp. 436-440, *Conway’s 1860-1905*, p. 39 and Brown, *Warrior to Dreadnought*, pp. 142, 148-149.

201 Parkes, p. 370.
cost effective, while small ships would provide more vessels for the same money, increase flexibility, and minimize the risks associated with the loss of any single ship. The emblematic public case was made by Captain Eardley-Wilmont, who worked in the Director of Naval Intelligence’s office, in a paper presented to the Royal United Service Institution, which subsequently published it in their Journal in August 1892.202

The Royal United Service Institution was (and is) a very important forum for the exchange of ideas on military and security issues. Originally called The Naval and Military Museum, it was founded by a group of senior officers in 1831, with the strong support of the Duke of Wellington and King William IV, to study the lessons of the Napoleonic Wars and “prove that the two professions have entered the lists of science.” The name was changed to the United Service Institution in 1839, and the group received a Royal Charter in 1860. The mission adopted for the Royal Charter was “the promotion and advancement of Naval and Military science and Literature.” Regular lectures and meetings, followed by a journal, quickly became forums for discussion, and the free expression of ideas by all members, senior and junior officers alike, provided the intellectual drive of the organization. By the 1890s a healthy percentage of officers in both services had joined, and the Institution had a secure place as an intellectual forum for the military services.203


Captain Eardly-Wilmont advocated ships of approximately 10,000 tons’ displacement (about the size of the Centurions) instead of large ships of 14,000-15,000 tons, like the Royal Sovereigns or the proposed Majestics. Smaller, cheaper ships would allow for roughly 12 moderately size ships to be purchased for the cost of 8 Royal Sovereigns, which would mean “four additional rams and 24 torpedo tubes.” The heaviest guns were unnecessary because smaller, quick-firing guns would render enemy ships unmanageable by destroying their unarmored portions and killing crew. While he acknowledged that protection would be sacrificed, it and the loss of firepower were reasonable sacrifices to get more ships.

Eardly-Wilmont’s argument also drew upon the experience of the Napoleonic Wars. He argued that the larger number of smaller 74-gun ships built, compared to ships with 100+ guns, demonstrated practically the superiority of larger numbers of smaller ships. Eardly-Wilmont also argued that 74-gun ships withstood blockading work better, had superior sailing qualities, and drew less water, but could still hold their own against heavier vessels. An appeal to practical experience was very powerful to naval officers, and practical experience was held to be the highest standard of proof within the Royal Navy.

This appeal to history foreshadows those made later by the “historical school” that arose in response to the growth of the “material school.” The disputes would become much fiercer and the intellectual ground much more sharply defined later when Admiral

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204 Cited by White by in “The Characteristics and Dimensions of Battleships,” TNA: PRO CAB 1/2/14.
John “Jackie” Fisher became First Sea Lord, but the roots of the two schools and their ideas can be seen clearly in the early 1890s. The “historical school” held that the concentration of effort on equipment was a waste of time and resources, and that what really mattered was the fighting spirit of the Navy, particularly the senior officers. History showed them that the quality of the men made vastly more difference than the quality of the ships.²⁰⁵

Eardly-Wilmont’s argument used a similar appeal. Smaller, well-handled ships, fought by superior officers and men, proved more capable than poorly handled larger ships. Therefore, the modern navy should not worry about having the biggest ships, the argument stated, but rather having good ships, which with superior numbers and the exceptional leadership and training found within the Royal Navy, would defeat whatever foreign navies might build. This appears to be an earlier, not yet fully articulated form of the argument that would be developed later.

William White again undertook a strong and detailed defense of large ships, this time in a minute completed in November of 1892. Many of his points reiterated those he had made just a few years before. Larger ships, White repeated, could carry more and heavier guns, and their greater protection, larger engines for higher speeds, and superior ability to move and fight in rough seas were better embodiments of concentration of

²⁰⁵ Good examples of the ideas of the historical school can be found in Admiral Sir Reginald Custance, *Lissa, the Yalu, and the Capital Ship* (Edinburgh: William Blackwood and Sons, 1910), who was also one of the opponents of the large battleship in the 1890s, or in Admiral Lord Charles Beresford, *The Betrayal, Being a Record of Facts Concerning Naval Policy and Administration from the year 1902 to the Present Time* (London: P.S. King and Son, 1912), p. 47.
force. He also emphasized that it had been policy not to build ships inferior in striking power or protection to those of other powers. In order to do this, large ships were needed. Furthermore, because British ships had a far greater range and coal capacity, and carried more equipment than their foreign counterparts, they needed to be larger than foreign ships, not just equal in size.206

White also addressed the argument from history advanced by Captain Eardly-Wilmont. He notes two issues that undermine Eardly-Wilmont’s proposition that as 74-gun ships were close enough to equality with 100+-gun ships to make greater numbers of ships the decisive factor, so 10,000 ton ships were close enough to equality with 14,000+ ton ships as to make having more smaller ships better than fewer larger ones. First, White notes that 74-gun ships were equal in defensive power to 100+-gun ships. There was little difference in the heavy oak timbers that were the structure and “armor” of both. Second, while smaller, 74-gun ships had fewer guns, they were relatively more powerful individually than the guns on French or Spanish 100+-gun ships. Finally, he noted that 74-gun ships could use their lowest tier of guns under conditions that 100+-gun ships could not, his example being the lee (downwind) side of the ship heeled (leaned over) under sail. Since their role, primarily blockading, emphasized seaworthiness and the ability to operate more effectively in foul weather, the smaller vessel minimized its offensive weakness and maximized its strengths. However, White goes further, and asserts that

under modern conditions larger ships are superior both offensively and defensively and are better ships in heavy weather, making this comparison to the past irrelevant.\textsuperscript{207}

As in 1889, the defenders of large ships carried the day. Planning went ahead for the first two \textit{Majestics}: “bigger, better, faster” ships along the pattern set by the \textit{Royal Sovereigns}. They have been called “the finest specimens of naval architecture of their day.”\textsuperscript{208} They were the largest warships built up to that time, with 412 feet total length and displacing 14,600 tons at normal draft. They were high freeboard ships, with their main guns in protected barbette mountings, could cruise at 16 knots, and could bunker up to 1,900 tons of coal.\textsuperscript{209} They fulfilled the vision of the battleship as an ocean going force capable of taking the battle to the enemy.

\textit{Conclusion}

When Parliament passed the Naval Defense Act in 1889 it intended to give the Royal Navy sufficient battleship strength to achieve superiority over its potential foes. It did not, however, provide detailed instructions to the Navy as to how those ships were to be built—that was a job for the Navy’s experts. Those experts, its Admirals and senior Captains, had a number of options available to them when it came time to design its ships. They had to sort through those options and determine what would best meet the Navy’s needs. The option chosen by the Navy was to build large ships with large guns

\textsuperscript{207} “The Characteristics and Dimensions of Battleships,” TNA: PRO CAB 1/2/14.

\textsuperscript{208} Parkes, p. 382

\textsuperscript{209} Conway’s 1860-1905, p. 34; Parkes, p. 381.
that were moderately protected, fast (for their size), and had high endurance. They were also capable of moving and fighting effectively in the open sea in all but the worst weather.

An examination of the process that made this decision reveals several important points. First, the Navy had institutionalized a strong system for making decisions. It combined the formal authority of the collective executive body of the Navy, the Board of Admiralty, and the informal practice of consulting widely among its other senior officers. This meant that decisions were made based on a wide base of knowledge and experience and were not dependent on the abilities (or subject to the whims) of one man. Admiral Hood, despite being the senior officer of the Navy, did not get his way but instead sought and then accepted the judgment of other senior naval officers. Decisions made through these established channels carried legitimacy both within and outside of the Navy.

Part of that institutionalization, but important in its own right, was the collective nature of the decision making and the collegial nature of the interaction of the individuals involved. The collegiality of debate meant that the Navy lessened the chances of creating factional rifts that would hurt the organization’s cohesion, and the compromises allowed it to hedge against majority opinion being wrong. Hood may have failed to convince the bulk of his colleagues that ships should be built with old style turrets and the heaviest armor, but the same officers who rejected his ideas for the best type of ship conceded that one ship should be made to his specifications.

This examination also finds that while this system was not dependent on the abilities of any one individual, it created an environment were an exceptional individual
could act and lead: at this time, William White, DNC. White was exceptionally talented as an engineer and ship designer, and was a very articulate man who could explain and defend his technical ideas. The Royal Navy was lucky to have him for those reasons alone. He took the lead and effectively defended the design decisions that created both the *Royal Sovereign* and the *Majestic* classes, against public criticism and Cabinet concerns about cost. What made White leader of the process was his ability to understand and manage the Naval officers around him. They jealously guarded their control over ship design as being within their professional prerogative and resented any civilian interference. In addition to his technical and communication talents, White overcame this with careful deference and by leading only where most officers wished to go.

Finally, while it is clear that the advocates of different battleship configurations had clear ideas of how those ships should be used to accomplish the Navy’s goals, these ideas were only implicit in their arguments about the basic design configuration for battleships. The debate led by Hood and White over the use of old style turrets or barbettes did not begin with a discussion over how the ships would be used, followed by a debate about what design would best serve in that role, but instead skipped right to the debate of which was best. This could have been a major failing, resulting in a muddled design that served neither purpose well, but it was not, because both men had clear ideas which were implicitly shared and understood by other officers. Thus, the ships that emerged had a clear operational role that was well understood by the Navy.
The process was effective in giving the Navy good ships, good enough that the Navy copied them, with improvements, for decades. The battleships built for the Naval Defense Act of 1889 and the Spencer Program in 1893 set the basic pattern for the size and role of battleships for the Royal Navy. While the *Dreadnought* represented a significant modification of the elements of the battleship (e.g. type of engines, type of guns), it did not fundamentally change the battleship’s shape or operational methods. Thus, the process that determined the basic pattern for the battleships produced for the Naval Defense Act and Spencer Program determined the basic patterns for battleships through the last one built for the Royal Navy, the *Vanguard*, commissioned in 1946. That the pattern remained in use for decades and survived the lessons of two major wars is a tribute to the Royal Navy’s decision making system’s ability to “get it right.”
Chapter 3: Integrating New Technology
What is “Better?”

Introduction

While the debates about the basic “shape” of the battleship were being worked out, the Navy was also wrestling with numerous technological changes in the various systems needed for battleships to fight effectively. Major changes in weapons technology, armor, and electrical technology all demanded attention, and the Royal Navy constantly faced dilemmas as it struggled to adapt. It needed to figure out exactly which new technology was going to produce better equipment with proper development, and which would be a dead end that provided nothing useful. Then, it needed to choose when to switch to new equipment from older equipment that was already readily available, operated dependably, and was tough enough to function in the harsh conditions at sea or in combat. Both decisions were and are very difficult, much more difficult than observers generally recognize with the benefit of hindsight. Pressure on Navy leadership compounded the difficulty, as a poor decision by the men safeguarding British security could prove catastrophic. The Navy adopted and adapted new technology at a deliberate pace, balancing the desire for better weapons systems with the need for reliable ones.
In part because of the weight of this responsibility, Navy leadership had a strong tendency to value reliability and robustness over other qualities. It wanted a very high degree of confidence that its ships would do what they were expected to do and not surprise its own fleet and ship commanders. Likewise, it wanted its ships to have a high rate of readiness, that is, to be generally available and ready to fight as opposed to being unavailable for maintenance or other issues. Reliability and robustness provided for both goals.

The difficulties involved in choosing new technology and the caution born of responsibility meant that the Royal Navy was not an early adapter of new technology, and was an important reason why its leadership acquired a reputation for being technologically reactionary. Such an assessment, however, overlooks the penalties imposed by jumping to new technology too quickly, issues that senior naval officers understood. Chasing technology that ultimately fails wastes limited resources: working out the “bugs” in new technology can be costly, difficult, and time consuming. The Navy needed effective ships ready to fight; it could not afford to take chances with new technology until that technology was better than the older technology in use.

“Better” is an ambiguous term that can mean any number of things depending on the circumstances and the needs and desires of the person or persons who are making the decision about what “better” is. For the Royal Navy, a piece of equipment (or a technique for using it) was “better” if it met any one of a number of different criteria. The first was effectiveness: whether equipment was more successful at accomplishing a given task. For example, guns were better if they could fire more rapidly, do more
damage because of more penetrating power, or deliver a higher amount of explosive to a
target; engines were better if they could deliver more speed for a given amount of steam.
Better might also mean easier to use, allowing fewer or less well-trained personnel to
accomplish a task, or putting less strain on personnel. An item might be better if it
performed equivalently to an old item for a lower cost, and anything that was lighter but
still performed as well was better. Better might also mean more reliable or robust:
breaking down less under normal usage, being easier to maintain, or continuing to work
after sustaining damage from either battle or the rough environment of a ship at sea.
Better might also mean more suited to the projected particular task the item might have to
perform. The previous chapter described the debate between seaworthiness and
protection, a debate that was ultimately resolved by deciding where and how a ship was
expected to fight. Essentially, anything that enhanced combat ability, combat readiness,
or stretched limited resources further was better.

Rarely, however, was it possible to assess any facet of an item or technique in
isolation. Tradeoffs between features were constant, and formed the core issues of the
decisions the Navy made about ships’ systems. For instance, a lighter item might be less
robust or more expensive; was the reduced weight worth the cost in degradation of other
features? This was a manifestation at the micro level of the same issues that existed at
the macro level on a ship. Ships were designed around tradeoffs between firepower,
speed, protection, and endurance. Each system on a ship demanded tradeoffs between
features in a similar way. An item that was clearly better in one way might not be
deemed better overall because the degradation of other features was unacceptably high.
This could even be the case if an improvement was significant but imposed costs, though seemingly small, that caused a feature to drop below a minimal accepted level. New smokeless propellants to replace black powder might impart far more energy to projectiles using a smaller sized charge, but if smokeless propellant exploded spontaneously under common conditions on board ship, such as high temperature or jarring shocks from the sea, it was not better. Similarly, a light that was inexpensive to make and gave off more illumination but was not robust enough to withstand rough handling from the weather or combat was also unacceptable. Better, then, was often a matter of judgment about the tradeoffs needed.

The Navy’s work with and adoption of new technologies for ship equipment showed certain patterns beyond a preference for reliability. Like that to select a better basic ship design, the process of selecting better systems was collective and collegial, bureaucratic, and with little sense of urgency, focusing on the Board of Admiralty but dependent on a wider “college” of senior officers. Given the difficulties involved in the technological decisions these traits were valuable, because they ensured due deliberation and brought in many experienced opinions before final decisions were made. While decision-making was dominated by naval officers, it was led in important ways by a civilian, William White, DNC, who provided a level of knowledge that greatly facilitated the technological sorting process. Though the process was structured to minimize the dependence on any given individual, the particular talents and faults of an individual could emerge. White was a positive influence; Captain (later Admiral) A.K. Wilson was
a negative one, holding up torpedoes because of his perfectionist tendencies, and thereby allowing the best to become proverbial enemy to the good.

While cautious, the leadership of the Royal Navy was generally anxious to acquire new equipment despite a few “cranky” Admirals (and Captains), once convinced it was better. Yet delays were endemic, most often because even promising new technology usually needed development to work out faults in the equipment or the manufacturing process. For a large, complicated system like a battleship’s main guns, this could mean years of effort. Naval decision makers were often faced with a choice between what was available within a certain limited lead-time or something new and better. Usually, old and reliable trumped new and potentially unready. A second contributor to delays was the lethargy and indifference of the Ordnance establishment, dominated by the War Office. The Navy had begun to break free from its dependence on the War Office, but success was still only partial.

Usually, the Navy reacted to technological change in other sectors. Sometimes, new technology introduced either by private industry or abroad was adopted after the Navy considered it ready for use, as happened with new developments in armor. Other times, the Navy recognized the importance of new technology introduced elsewhere and targeted it for introduction, but only after others undertook further development. “Smokeless” powder was such a technology. An exception to this was range-finding equipment for guns, for which the Navy did go out looking. Even here, however, the Navy did not develop the equipment itself but rather called for submissions from the private sector. Another exception was electrical equipment. The Navy reacted to
developments in the use of electricity, but it found itself in the position of developing some of its own equipment in house because its needs for robust equipment were so extreme. It also was willing to experiment with electrical technology, testing it against older methods, to gain information for the day, which it knew was very likely, that electricity would replace steam and hydraulics for many functions. The leadership of the Royal Navy was not in a hurry to change—it had no need to be. Its position of superiority allowed it to wait and move when it was sure, and both its weight of responsibility and its traditions encouraged caution. The leadership, however, did move the Navy forward at a measured, deliberate pace.

Guns and Torpedoes

Weapons were, at least in the minds of officers of the Royal Navy, the most important system on the battleship. Indeed, the battleship’s reason for existence was to carry weapons with which to attack the enemy: as Fisher wrote, “If you haven’t got the guns, what’s the good of building the ships?”

However, weapons technology was in flux. Smokeless gunpowder had recently been developed, and its ballistic properties were vastly superior to the older style gunpowder propellants, which it surely would replace. Here the new technology collided with another issue: a complicated ordnance system, dominated by the Army, which was relatively indifferent to naval needs. These factors forced the Navy to settle for good, but not optimum, guns. Torpedoes were also undergoing major changes as the still primitive technology improved, but they were

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complicated and delicate weapons and proved difficult to perfect. Overall the Navy did make progress in weapons technology, but much remained to improve.

The pivotal meeting of the Board of Admiralty and other key members of the Royal Naval college in November 1888, intended to set the major design points for the Naval Defense Act battleships, had more to decide than the important issue of turrets versus barbettes. Armaments, both main and secondary, were topics of discussion, and the main guns, the core of the battleship’s offensive punch, were of special concern. The Board had wanted to upgrade the older model 13.5” gun used in most of the Admiral class. That would require the design of a new gun, which in turn would require the adoption of a smokeless powder.

Changes in the gun design were necessary due to differences in the nature of combustion of the different types of propellant. Old style gunpowder, also known as black powder—a mixture of approximately 75% saltpeter, 15% charcoal, and 10% sulfur—had been in use for centuries. It was well understood on a practical, if not theoretical, level: gunners, gun founders, and other experts knew how it behaved under a variety of circumstances even if they did not know the chemistry that could tell them why. It burned quickly, necessitating a gun with a very strong breech that needed only a relatively short barrel. Starting in the 1860s, new formulations of gunpowder that

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burned more slowly, called brown powder, were developed. Powder grains were larger and specially shaped, and the chemical content of the powder itself was ultimately changed, with the amount of sulfur being cut by about 70%. These innovations yielded slower burning powder and more complete combustion. This eased the highest pressures at the breech end of the gun barrel and accelerated the projectile for a longer distance down the barrel of the gun, which required changes in the shape and size of the gun to optimize performance.²¹³

However, by 1889 advances in explosives technology had made both of these powder types obsolescent. Nitrocellulose based explosives, which had been in existence for about 40 years, were first turned into useful propellants in France in 1886, when a gelatinized nitrocellulose propellant, poudre B (now known as pyrocellulose) was introduced. Though not smokeless, nitrocellulose-based propellants produced far less smoke and residue than black or brown powders. They also burned much more slowly than black powder, providing greater muzzle velocity for the projectile with smaller charges and lower peak pressures, because they continued to add thrust to the projectile for a longer distance down the barrel of the gun. There were a great many variations developed either of single-base straight nitrocellulose alone or double-base mixtures of

nitrocellulose and nitroglycerin; the first of these, ballistite, was invented by Alfred Nobel in 1888. ²¹⁴

Because of these changes to the nature of propellant powder, new configurations were needed for guns. Guns grew from 20-25 caliber for large guns using black powder to around thirty caliber with brown powder, and ultimately up to 50 caliber for nitrocellulose powders, in order to take advantage of the slower burn and gain the most velocity for the projectile. ²¹⁵ Smaller charges meant that powder chambers, the very end of the bore where the powder is located behind the projectile, had to be resized and shaped to yield optimum performance. ²¹⁶

These changes required that the explosive properties of the powder be known, which meant determining the type of powder to be used. That involved either selecting or developing a nitrocellulose propellant, empirically testing it in various guns, ensuring it could be used safely under service conditions, and finalizing the manufacturing process to make certain that it could be produced in mass quantities at a reasonable cost. All of this took time, and, more importantly, was not under the complete control of the Navy.


²¹⁵ Caliber in this context is the length of the gun bore (the inside tube of the gun) in multiples of the bore diameter. A 20-caliber gun would thus have a bore length 20 times its diameter.

²¹⁶ Records Created by the Ministry of Supply and Successors, the Ordnance Board, and Related Bodies: Ordnance Committee Reports, 1894-1895, May 21, 1894, The National Archives: Public Record Office (TNA: PRO) SUPP 6/108.
In addition to shifting technology, the ordnance situation for the Navy was administratively and bureaucratically complex. After the Crimean War, the War Office controlled all military ordnance, primarily for reasons of economy.\textsuperscript{217} Both services were purchasing from the same suppliers, and it was reasonable to have only one office evaluating and purchasing ordnance. This was not as outlandish as it seemed, as the Navy had been dependent on a usually independent Ordnance Board from the 15\textsuperscript{th} century through 1855.\textsuperscript{218} Since all ordnance was budgeted through the War Office, there were conflicts over spending priorities. A joint ordnance committee was formed in 1879, and in 1882 naval ordnance was switched to the Navy budget and the Navy was given responsibility over ordnance design. The Naval Ordnance Department was established in 1886 under the office of the Controller, which, in theory, completed the transition and firmly established Naval responsibility for its own ordnance.\textsuperscript{219}

In reality, the final steps of the transition were not so easy, with difficulties in the transfer of budgetary and accounting responsibilities. The War Office, either through indifference or unwillingness to put forth the required effort, did not completely accommodate the change. The terms of the Naval Defense Act finally required the War Office to make the accounting changes, yet the War Office took no action. Only after a


letter from the Board of Admiralty to the Treasury in January of 1890 asking it to enforce the terms of the Act was the problem finally resolved.\textsuperscript{220}

There were still complications, though. The joint Ordnance Committee was retained, and it continued to conduct the vast majority of ordnance research, development, and testing—including submissions from the private sector.\textsuperscript{221} While it was a joint committee, the Chair was an Army officer and most of the facilities at its disposal belonged to the Army. Committee priorities thus tended to be the Army’s priorities, as the Army called upon the Committee’s services more and the overwhelming majority of Committee business was irrelevant to the Navy.\textsuperscript{222} Naval needs were not a priority for the Committee: the Director of Naval Ordnance enumerated a list of seven items that had been delayed two to three years by lack of progress from the Committee in early 1889, and delays continued into the 1890s.\textsuperscript{223} The Navy was heavily reliant on an

\textsuperscript{220} Board of Admiralty, Minutes and Memoranda: Admiralty Board and General Minutes, 1890, January 1890, ADM 167/22 TNA: PRO.

\textsuperscript{221} See Ordnance Committee Reports, 1890-1907, TNA: PRO SUPP 6/104 to SUPP 6/115 for Ordnance Committee Reports from 1890 to 1907 and Board of Admiralty: Monthly Records and Principal Questions Dealt with by the Director of Naval Ordnance, 1888-1907, TNA: PRO ADM 256/21 to ADM 256/44.

\textsuperscript{222} For example, see Ordnance Committee Reports: The Annual Reports of the President of the Ordnance Committee for 1889 and 1890 TNA: PRO SUPP 6/54; subsequent years through 1907 (TNA: PRO SUPP 6/ 55 to SUPP 6/67) show similar patters. The vast majority of his discussion concerns topics important to the Army, very little is relevant to the Navy. See also Ordnance Committee Reports, TNA: PRO SUPP 6/103 through SUPP 6/115 covering the years 1889-1907.

\textsuperscript{223} For example, Letter from the DNO to the War Office, March 1889 listing items delayed by lack of Ordnance Committee approval, TNA: PRO ADM 256/21, or Memo from DNO to War Office on Expediting Cordite Trials, April 1890, TNA: PRO ADM
indifferent or distracted organization for its guns and their supporting equipment, which were the most important sub-system for the Navy’s paramount weapons system, its battleships.

Smokeless powder was one of the items that had been seriously delayed, much to the Navy’s frustration. In 1888, the Secretary of State for War appointed a Committee on Explosives, reporting to the Director of Artillery, to adopt a smokeless propellant for use by the British armed services. It tested a large number of different versions of smokeless explosives, and rejected them as being flawed in some way. Sir Fredrick Able and Sir James Dewar, working on the Committee, developed cordite in 1889. Cordite Mark I was 37% nitrocellulose, 58% nitroglycerin and 5% petroleum jelly, and was very closely related to ballistite. Initial tests for efficacy and basic safety proceeded successfully, but it was too late for use with the Royal Sovereigns. It would be years before a new gun, designed around cordite, could be available, and at least some of the battleships of the Naval Defense Act would be ready long before.

256/23 or “Précis of Correspondence Relating to the Introduction of New Design 12-inch Wire Wound Gun; Delays Caused by War Office,” TNA: PRO ADM 256/28.

224 Monthly Records and Principal Questions Dealt with by the Director of Naval Ordnance, January to June 1889 TNA: PRO ADM 256/21, July to December 1889, TNA: PRO ADM 256/22, and January to June 1890, TNA: PRO ADM 256/23.


226 No relation to the family of whiskey distillers.

Delays to main guns were a persistent problem for the Royal Navy in the 1870s and 1880s, and caused significant problems in completing ships that were otherwise finished. A number of Admiral class ships suffered delays of years while waiting for their guns, and both the last member of the class (the Benbow) and the Victoria class turret ships were armed with 16.25-inch main guns, which had problems with drooping and wear, because insufficient 13.5-inch guns were available for them. To avoid the expense associated with late delivery of guns, as well as to ensure the ship was ready in a timely manner, the older style 13.5 inch guns, which were no longer in short supply, were used.

This illustrates a key limitation on warship design, or indeed the design of any complex piece of equipment. It was not enough to have designed the gun. The facilities and engineering capability had to exist to manufacture it with sufficient speed, in acceptable quantity, and at a reasonable price. Historians of technology discuss technology not simply as the piece of equipment but as a complete system surrounding that equipment. The systems include the ability to manufacture and distribute it, accessory and auxiliary equipment and services, and techniques for and goals of its use.


229 Brown, Warrior to Dreadnought, p. 127.
In other words, technology includes not just the equipment but the infrastructure and context.\textsuperscript{230}

While the Board may not have thought explicitly in those terms, it did act on them. Earlier difficulties reminded the Board that a gun, no matter how good, is of no use if it is not finished, installed, and prepared for use. The Navy had learned that “settling” for older but reliable technology produced operational warships, in the quantity required and when they were needed. Naval leaders were aware that a functional weapon in service was better than the “best” weapon that was unavailable. The Board was also cognizant of the fact that accepting a delay in the weapon itself would impede the service of an entire weapons/combat system, which is what the battleship was. The decision to accept older technology in order to proceed with other innovations was an intelligent approach to the problem of dealing with rapidly developing technical changes--use the new equipment and technology when it can be integrated into a functional system and, until then, continue using what already works.

Secondary armament had recently also become an important part of battleship weaponry, and the Board faced a similar issue with regard to the heaviest guns to be used for it.\textsuperscript{231} In 1889 and 1890 the Navy was waiting for an upgraded gun using smokeless


\textsuperscript{231} \textit{Colossus} class battleships, laid down in 1879, were the first British battleships to have significant secondary armament. Secondary armament was a reaction to the torpedo and small, swift and maneuverable torpedo-boats, which were difficult to defend against with slow firing, slow aiming, heavy guns. See Roberts, “Warships of Steel,” p. 95.
propellant, and it was questionable whether it would be ready for installation on the ships.

In this instance, however, the Board decided to take the risk and plan for the new weapon.\textsuperscript{232} The Board took the opposite path here because the relative superiority of the new gun over the old was greater, and the risk that the entire ship would be held up was lower.

The gun the Board wanted was a 6-inch quick-firing (QF) cannon. QF guns were a recent and significant improvement over standard breech loading guns; they were designed for rapid loading and a rapid rate of fire, usually by using a brass cartridge that contained both the propellant and projectile (though not always – many British versions still used a separate powder and projectile), a quick and easy breech mechanism, and a mounting suitable for rapid aim and shooting. The difference in rate of fire was very large – a 4.7-inch QF gun, the largest then available, fired eight times faster than a comparable non-QF gun.\textsuperscript{233} The 6-inch QF gun was delayed by the Navy’s anticipation of smokeless propellant. It did not want to develop a gun using older powders only for it to become immediately obsolete by the introduction of new propellants which would require a new gun design.\textsuperscript{234} The alternatives to the 6-inch QF gun were significantly

\textsuperscript{232} Minute From DNO to War Office, February 1890, TNA: PRO ADM 256/23.


\textsuperscript{234} Minute by DNO: Remarks by DNO on letter from Director of Artillery, February 1889, TNA: PRO ADM 256/21 and Minute from DNO to Controller, October 1889, TNA: PRO ADM 256/22.
inferior. The 6” breach loader was much slower and the 4.7-inch QF gun, which was available, was considered too small.235

Set against the large margin of superiority enjoyed by the 6-inch QF gun was the lower risk that the entire ship would be delayed. Like the anticipated new 12-inch main gun, the six-inch QF was put on hold while the smokeless propellant was chosen and basic testing was done. However, tests of the propellant would proceed more rapidly with the smaller gun, making it ready for use in that gun sooner than in the larger one.236 The design and construction of the smaller gun was also much faster, which reduced the time lag between selection of a powder and production of a useable weapon, so it could be ready more quickly.

The consequences of a delay to the six-inch gun were also significantly lower than a delay to the main guns, further reducing the risk involved in waiting for it. Six-inch breach loading guns or 4.7-inch QF guns could be readily substituted if the six-inch QF gun were completely unready. The alternative guns were either the same size or smaller, and would fit within volume and weight limits easily. Then, at a later time, six-inch QF guns could be substituted.237


237 Series of memos between the DNO, Controller and DNC, Fall 1889, TNA: PRO ADM 256/22.
A ship’s guns are themselves just a part of a complex set of machinery, which includes their mountings, movement machinery, and loading apparatus. Despite being sidetracks from the main path of battleship development, the *Centurion* and *Barfleur*, both second-class battleships authorized by the Naval Defense Act, were used to introduce features in gun mountings that were later adopted more generally. The *Centurion* class’s main armament was mounted on a barbette, like the *Royal Sovereigns*, but because they were smaller (only 10”) the guns were hand loaded and had emergency hand training to supplement the steam-driven training motor. This exposed far more of the gun crew on the deck than in the *Royal Sovereigns*. To offset this, White added roofed shields, which covered three sides and had an open back, to the main gun mountings.\(^{238}\) This was the first step in the development of the modern barbette-turret, which was completed with the *Majestic* class’s gun shields, which were fully covered and armored.

The other advance was the introduction of all-position loading. Previously, guns needed to be trained fore and aft (and to a specific elevation) in order to accommodate the loading mechanism of the guns. Whitworths, the contractor building the new gun mounts, built the loading chamber under the gun platform and had it revolve with the gun. The ammunition passed up the center and out an incline to the loading chamber.\(^{239}\) This was a considerable improvement, allowing for a significantly higher rate of fire.

\(^{238}\) Brown, *Warrior to Dreadnought*, 132.

\(^{239}\) Parkes, pp. 367-368.
This episode is also an interesting example of the relationship between the Navy and its suppliers. The Navy was often dependent on the engineering expertise of its contractors for technical improvements, as this case illustrates. The Navy had few resources engaged in research and development, especially in the realm of engineering.²⁴⁰

All-position loading was not repeated with the Renown or the early ships of the Majestic class, though other innovations were. The early Majestics had a provision for a small amount of ammunition within the barbette shield for all-around hand loading.²⁴¹ A break in the ammunition hoist was added for safety.²⁴² Powered backup training gear was introduced at the prompting of an article in The Times complaining about its absence.²⁴³ The last two ships of the Majestic class, the Caesar and Illustrious, laid down in 1895, returned to round barbettes and all-around loading of the guns, though their angle of loading was still fixed. From then on, powered all-around loading was standard.²⁴⁴

Advances were also made on other equipment that was part of the gunnery system, or as in this case, would become part of it. At this time, naval gunnery was still


²⁴¹ Parkes, p. 384.

²⁴² Brown, Warrior to Dreadnought, p. 153.

²⁴³ Ships Cover No. 136, Majestic Class, National Maritime Museum, Greenwich.

²⁴⁴ Parkes, p. 384.
operating on many traditional principles. Ranges were short, and aiming was still done by eye. The guns, however, were vastly more capable and could easily fire further than this, but it was not possible to gauge such ranges by eye. The development of smokeless propellants would soon give guns even longer ranges. Thus, the guns performed vastly below their potential. This situation was a problem. Guns, themselves part of the technological system of the warship, were themselves a complex system. There was (and is) a great deal of knowledge and infrastructure needed for building and using large guns, including very intricate scientific and engineering knowledge of metallurgy, complex industrial systems, and the knowledge and infrastructure to produce and use other systems complex in their own right (e.g. mountings, propellant, and projectiles).

The fact that guns could not be used up to their full potential was the result of what Thomas Hughes characterizes as a “reverse salient,” in which one part of a system lags in development behind the other parts, which limits the system’s capabilities.\textsuperscript{245} The problem here, hitting targets at a distance that the guns were capable of shooting, has a number of parts: accurately shooting a gun that is constantly moving and changing directions in three dimensions (as the ship interacts with the sea), the ability to estimate ranges accurately and quickly, and ultimately the capability to estimate where the target will be after the delay between when the shot is fired and when it hits the target (when the

target is far enough away for travel time of the projectile to matter). In 1889 the Royal Navy began to take steps to address one of these issues—finding ranges. Surprisingly, that June the Ordnance Committee, usually indifferent to naval needs, suggested that a range finder would be useful for the Navy (it made no reference to any potential use for the Army) and inquired of the Director of Artillery if it should look into one.\footnote{Correspondence between Ordnance Committee and Director of Artillery and Controller, June 1889, TNA: PRO ADM 256/22.} Note that the Committee directed its inquiry to the War Office, not the Admiralty. This is a clear indication of where the lines of responsibility ran.

The Director of Artillery referred the question to the DNO, at that time Captain John “Jackie” Fisher. Fisher in turn referred the question to the Captain of the Excellent, Captain Compton Domvile. A week later, Domvile wrote that he thought that the Committee’s interest must have been spurred by a description of an American range finder designed by Lieutenant Fisk of the United States Navy. Domvile thought that device would be physically unsuitable for the Navy. He went further to note that he did not think a range finder would be valuable, as finding ranges based on fall of shot was far more flexible and did not rely on delicate equipment. He also noted that another range finder, Christie’s Range Finder, was in the possession of the Excellent and while experiments had been carried out, they were not done with any particular care for the proper preparation of the equipment. Considering that Domvile would have been responsible for properly conducted trials, this speaks volumes about the importance he placed on it. Domvile concluded that the Committee could look into it if it liked, but he
was clearly uninterested. Fisher passed Domville’s memorandum along to the Director of Artillery. ²⁴⁷

Ten days later, however, Fisher addressed a follow-up memo to the Director of Artillery of a very different flavor. Fisher wrote that if the Committee “could see their way to obtaining a simple and easily manipulated range-finder suitable for use on board ship it would be a great advantage,” a very different opinion from Domville’s. Fisher remained interested. Slightly more than a year later, in July 1890, Domville submitted a formal report on Christie’s range finder. It was not consistent from user to user and the ship’s motion made it difficult to use. Domville concluded that it was not suitable. In August, Fisher again attached a follow-up memo calling a range finder “a most necessary requirement.” ²⁴⁹

The contrast between Domville and Fisher in their evaluations of the need for range finders brings out an important point with regard to the role of the individual in the Royal Navy’s decision-making process. The Navy had a highly structured bureaucracy where each position and department had a tightly defined role. In memoranda, officers are most frequently referred to by their respective posts (e.g. Director of Naval Ordnance, Controller) and not by their names. Some care would be taken in placing “sound” officers—those who understood and upheld the professional attitudes, standards, and

²⁴⁷ ibid.

²⁴⁸ Minute from DNO to Director of Artillery, July 1889, TNA: PRO ADM 256/22.

²⁴⁹ Addendum to Report from Captain of Excellent by DNO, August 1890, TNA: PRO ADM 256/24.
methods of the Navy and did not deviate too far from them—in a slot and, especially for more technical positions, placing an officer with the proper background and expertise. Given their common training and experience, few senior officers deviated from “soundness”—the few who did rarely achieved the level of authority to be involved in decisions at the highest level. In other words, there was a certain degree to which officers were considered interchangeable and the individuality of an officer was not a concern.

The Navy developed a strong institutional culture that aggressively indoctrinated officers in the “Navy” way of thinking, helping to promote this interchangeability. The resulting strength and narrowness of outlook has often been criticized for stamping out creative thought.²⁵⁰ This charge is justified, at least sometimes. However, the establishment of common channels of thought could also be valuable. In an organization in which individuals might be injured or killed undertaking their duties, it would have been important to have a ready replacement that could step in and assume any role needed. The predictability of a given officer’s action also had value. In the chaos of combat, where communication is difficult or impossible, it could be very helpful for individuals, especially leaders, to have some idea how those around them would act in

different types of situations. Even in the more prevalent peacetime operation of the Navy, uniformity and predictability had value. Officers moved from position to position, usually after only a few years at any given post, and having some type of institutional thought process eased the transitions, both for the individual officer and for those who needed to work with him—subordinates and superiors alike. The interchangeability of officers had value to the Navy, and it often meant that it was relatively unimportant which officer undertook the duties of any specific position.251

The Navy was not unique in having an element of interchangeability in its leadership class. Officers in the Army and senior personnel in the Foreign Office also shared a strong uniformity in attitude and worldview.252 In those departments, both of which recruited their personnel at a significantly older age than the Navy, the commonality of outlook was less dependent on training received as a member of the organization and more on the narrow social base from which they drew their recruits. This is not to say that the institutional culture of the Army and the Foreign Office officials did not reinforce the preexisting attitudes of their members, or to deny that the Navy also drew its officers from a similar fairly narrow social base—only to note the


relative importance of the Navy’s actively inculcating the common mind-set. Indeed, it can be argued that the “ruling class” of Victorian Britain, those in positions of power and authority in government, the military services, education, and business, shared a common set of assumptions about the world.\textsuperscript{253}

However, it was not always true that all naval officers thought similarly. Individuals did make a difference at times, and this was one example. Both Fisher and Domvile were experienced officers and generally well suited to their roles. Domvile had a distinguished career that included stints as Queen Victoria’s aide-de-camp and Commander-in-Chief of the Mediterranean fleet (his term immediately followed Fisher’s in 1902), and he retired as an Admiral and Knight Grand Cross of the Bath. There is no evidence that he was ever thought of as brilliant, but he was highly regarded enough to rise to the top levels of his profession.\textsuperscript{254} He was the prototypical “sound” officer.

Fisher, however, was probably the most individualistic and iconoclastic member of the Navy’s “college” in the late 19\textsuperscript{th} and early 20\textsuperscript{th} centuries. Indeed, influential officers, such as Admirals Reginald Custace, Cyprian Bridge, and his predecessor as First Sea Lord Walter Kerr disliked him enormously, and thought Fisher was too iconoclastic


\textsuperscript{254} Remember, Command of the Mediterranean Fleet was the premier Fleet Command in the Royal Navy before the redeployments of 1905. Domvile’s appointment to that post is all the evidence needed to prove he was well regarded.
and definitely not “sound” at all. Arthur Marder, of course, sees him as one of the very few forward thinking senior officers in the Navy, who dragged it kicking and screaming into the 20th century and prepared it for the task of fighting World War I. There were and are a large variety of opinions in between. Fisher had “demonic” energy and enthusiasm, and was absolutely convinced of the correctness of his own ideas. He was a great modernizer, who believed new technology was an opportunity and not a curse, and he did do a great deal to prepare the Royal Navy for the War. However, he was an uncritical enthusiast for the “new,” and was poor at distinguishing the practical from the impractical. He was very personable to his superiors and concerned for the well being of juniors but was unable to be diplomatic and brooked no opposition. Such dictatorial tendencies damaged the collegiality of the officer corps in the decade before World War I.

Fisher’s enthusiastic but shallow strategic thinking brought important advances in naval readiness, but his blind spots left the Navy more unprepared for the War than it

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256 Lambert, Revolution, p. 91.

257 Marder, Anatomy; Marder, From Dreadnought to Scapa Flow; Marder, Fear God and Dread Nought, the Correspondence of Admiral of the Fleet Lord Fisher of Kilverstone, 3 vols. (London: Jonathan Cape, 1952-1959).
should have been. N. A. M. Rodger wrote, “Under firm supervision, Fisher was almost
entirely a force for good. Hardly anybody, however, was able to exercise firm
supervision over such a man.” This encapsulates Fisher’s personality and role within
the Navy well—Fisher’s negative qualities needed to be controlled to harness his positive
ones. When they were, he was an outstanding leader; when they were not, he could be a
significant problem.

As far as range finders were concerned, Domvile thought them unnecessary.

Spotting the fall of shot and adjusting estimated range accordingly, which was the
traditional means of correcting range estimates, was good enough for him. It worked
reliably enough so there was no need for something new—something that would certainly
have been more complicated, more expensive, and would have needed new training and
methods to use. He had no reason to think that the improvement in finding ranges would
compensate for the trouble of introducing new equipment and methods.

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259 Reginald Bacon, *The Life of Lord Fisher of Kilverstone*, 2 vols. (London: Hodder and
Stoughton, 1929); Ruddock McKay, *Fisher of Kilverstone* (London: Oxford University
Press, 1973). The biographies by Bacon and McKay are generally considered the
fundamental biographies of Fisher. Further assessment of Fisher, both positive and
negative can be found in, for example, Jon Tetsuro Sumida, *In Defense of Naval
Supremacy* (Boston: Unwin Hyman, 1989); N. Lambert, *Sir John Fisher’s Naval
Revolution*; Barry M. Gough, “Admiral Sir (later Baron) John Arbuthnot Fisher (1904-
1910; 1914-1915),” in Malcolm Murfett, ed., *The First Sea Lords from Fisher to

260 Memo from Captain of *Excellent* to DNO, June 1889, TNA: PRO ADM 256/22.
Fisher, though, was enamored with new technology and would think very differently about the potential uses for a new piece of equipment. He was much more likely to look at the positives and less likely to assess the balance of the negatives adequately. Fisher, too, was looking ahead. Torpedoes were already thought of as a menace with a range up to 1,000 yards, and there was every expectation of improvement. Since effective gunnery ranges (those where the guns could be said to have a reasonable chance of hitting a target) were at most 2,000 yards and probably closer to 1,500 yards, something would need to be done to increase effective gun range to keep it ahead of any growth in torpedo range. Also, since effective gunnery range was already well below the maximum ranges of shipboard guns (the guns could shoot much further, but had little hope of hitting), any improvement that could enhance aiming and increase effective range would be valuable and not require any other upgrades in guns or their auxiliary equipment. It was also quite evident that the new smokeless nitrocellulose based propellant powders would increase the maximum range of guns. Thus Fisher, always looking for technological progress, was excited, and pushed forward the process of acquiring a range finder when Domvile, as most other officers probably would have done, ignored it.

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262 Padfield, p. 211.
Later that fall the Ordnance Committee, with the support of DNO Fisher, decided to make a public call for a range finding device. April and May of 1891 were taken up with negotiations between the Ordnance Committee, the Director of Naval Ordnance, and the War Office about the wording of the specifications of the device, circulation of the public notice, and what department would be responsible for accepting submissions, which ended up being the Director of Army Contracts. The advertisement was published in twelve newspapers and journals (including the Times) on or about June 3, and a notice was sent to a number of prominent individuals and firms involved in optics, arms, or invention. It directed that submissions should be made by August 10, 1891 and that a device should be ready for trial within six months of that date.\textsuperscript{263}

Fisher was clearly interested in the idea, even if Domvile was not. However, Fisher left the initiative with the Ordnance Committee and depended on the War Office to do the legwork. The advertisement was made through the War Office and submissions were to go there as well. Given the very low number of staff at the Admiralty, it is likely that the Naval Ordnance Department did not have the workforce or the expertise to handle the process of making a public announcement of this sort, or an orderly means of accepting submitted inventions.\textsuperscript{264} Fisher, burdened with the additional demands of the department, had to depend on two other organizations, neither of which had a strong

\textsuperscript{263} Correspondence between DNO, Ordnance Committee and Director of Army Contracts, April and May 1891, TNA: PRO ADM 256/25.

record of being responsive to the Navy’s needs, to move forward with a piece of
equipment he regarded as very important to the future of naval gunnery.

Six months later, in February 1892, the Ordnance Committee had screened the
submissions, and pronounced four of them worthy of further investigation. The DNO, by
then Captain Domville, therefore suggested forming a committee to conduct trials. He
recommended using the naval members of the Ordnance Committee plus two additional
officers, including a Captain currently in command of a vessel. The Board agreed, and
appointed Captain Ernst Rice of the Pembroke as well as another officer to join the three
naval members of the Ordnance Committee, Rear-Admiral H. F. Cleveland and two
Captains, to investigate the range finders.265

The Committee ran shore trials in harbor on the Arethusa, a small cruiser, on the
instruments during March and April of 1892. The trials were complicated by the fact that
two instruments, including a fifth one submitted late by a naval lieutenant, could not
work under harbor conditions. The Committee found instruments that required more than
one observer to be cumbersome and difficult to coordinate, and strongly recommended
against them. The Committee also found that both single observer instruments tried were
worthy of further trial, and recommended that they and the untried instrument, which
could be worked by a single observer, be given further trial by the Excellent.266

265 Correspondence between DNO, Board of Admiralty, War Office, Commander-in-
Chief, Sheerness, February 1892, TNA: PRO ADM 256/27.
266 “Report of Committee on Naval Range Finders,” June 1892, TNA: PRO SUPP 6/106.
The *Excellent* carried out a vigorous month-long shore trial, after which the two single observer range finders were sent out on gunboats and evaluated there. The Captain of the *Excellent* recommended the Barr and Stroud range finder for further trials. This was a coincidence type range finder, in which vertical lines shown as split had to be focused until seen as unbroken, at which point the range was read. It had two sights 60 inches apart, and was easy to use even when the ship was in motion, relatively immune to changes in temperature, useful at night if minimal light were available, portable, pivot mounted, making it useful for any sighting in any direction, and accurate to within one percent at 3000 yards. It was mounted on the *Blenheim* during maneuvers in the summer of 1893, where it performed well and the Captain reported “very strongly” in favor of it.\(^{267}\) The instrument was subject to further tests, but it was adopted. Improved versions were the standard range finding instruments up to World War I.

One of the instruments that were rejected, the Fiske range finder, also received a second look. Fiske’s representatives in Great Britain inquired in July 1892 why his instrument was rejected, and complained that the instrument was not given a trial at sea, which broke the trial conditions. The Admiralty replied that it had made no promises of trial at sea, and that two other systems were also eliminated from further consideration. Fiske’s representatives then requested a sea trial at their own expense. After consulting with a government lawyer, the petition was granted and the *Alexandra* was selected to host the trial in November of 1892. It was almost a year later, in September 1893, before the instrument was ready for trial. Once trials began, it fell out of adjustment quickly,

\(^{267}\) Minute from DNO to Director of Artillery, TNA: PRO ADM 256/29.
and did not perform well enough to overcome the Range Finder Committee’s negative report.\textsuperscript{268}

The testing process was slow, but effective. Testing took well over a year to complete once the Navy began, and it does not appear to have been carried out with any sense of urgency. It was, however, exhaustive, not just delayed. There were two rounds of shore testing, not including the preliminary screening by the Ordnance Committee, and sea testing for two of the instruments investigated. It involved an Admiral, five Captains, two ships, several smaller boats, and the staff of the \textit{Excellent}.\textsuperscript{269} Many senior officers contributed, though undoubtedly the opinions of the Captain of the \textit{Excellent} and Admiral Cleveland, who was serving as vice-chairman of the Ordnance Committee, carried the most weight. When the maker of one of the devices, Lieutenant Fiske, appealed for a second examination, it was granted. While it does not appear that those trials were carried out with quite the enthusiasm of the trials on the Barr and Stroud instrument, they were nonetheless conducted.\textsuperscript{270} While one instrument was completely untried, its need for specific conditions for use could be considered a serious failing. The result was that

\textsuperscript{268} “Précis of Correspondence between Lieutenant Fiske’s representatives, Board of Admiralty, President of Range Finder Committee, Admiralty Solicitor and Captain of \textit{H.M.S. Alexandria},” July 1892 to November, 1893, TNA:PRO ADM 256/29.

\textsuperscript{269} Minute from DNO to Director of Artillery, TNA:PRO ADM 256/29; “Report of Committee on Naval Range Finders,” June 1892, TNA:PRO SUPP 6/106;”Précis of Correspondence between Lieutenant Fiske’s representatives, Board of Admiralty, President of Range Finder Committee, Admiralty Solicitor and Captain of \textit{H.M.S. Alexandria},” July 1892 to November, 1893, TNA:PRO ADM 256/29.

\textsuperscript{270} “Précis of Correspondence between Lieutenant Fiske’s representatives, Board of Admiralty, President of Range Finder Committee, Admiralty Solicitor and Captain of \textit{H.M.S. Alexandria},” July 1892 to November, 1893, TNA:PRO ADM 256/29.
the Navy adopted a good piece of equipment that was simple, robust, and relatively effective. The process might have been slow, but it was rigorous and produced good results.

The Navy was engaged in an even slower investigation into another weapon, the torpedo. Torpedoes and their delivery systems had helped create the debate about the future of battleships and prompted new ideas about how navies were to be used. Most of these issues and their impact on battleships in the 1890s have been discussed above, and broader exploration of these situations is outside the scope of this study. However, since battleships were also armed with torpedoes, their development needs some discussion here.

The Royal Navy commissioned a committee to investigate the designs of torpedoes in 1888, and it sat until 1894. The President of the Torpedo Design Committee was the Captain of the Vernon (in 1888, Captain Long), the Royal Navy’s torpedo, mine, and electrical school and experimental facility. The Captain of the Vernon was generally a member of the “college” of officers with the respect and seniority to have his opinions on matters taken seriously, at least in connection with his areas of expertise. At a certain level, he combined the role of experienced officer and technical expert.


This committee ran very extensive trials to determine what torpedo technology was best for the Navy.\textsuperscript{273} It was exhaustive in its approach, testing torpedoes of different materials, size, and charge. It also examined designs, guidance systems, and launching methods, compared torpedoes manufactured by Whitehead to those by the Royal Gun factory, submitted recommendations for modifications, and finally tested the altered models. Ultimately, it passed recommendations on the torpedo that was best suited for the service.\textsuperscript{274}

However, the Committee was very slow to make a recommendation. It was perfectionist, and only willing to recommend new weapons when they met extremely high standards.\textsuperscript{275} Captain A.K. Wilson, who became Captain of the \textit{Vernon} and President of the Committee shortly after it was established, wrote, “delay would appear to be of certainly less importance than the possible adoption of an inferior weapon.”\textsuperscript{276} Since the Committee found that it was very difficult to get a new, extremely complicated piece of technology to work well quickly, this attitude was perhaps a hindrance to getting an improved, if not perfect, weapon to the Fleet. This was another instance where the individual mattered. Wilson’s overcautiousness in allowing the best to become the enemy of the good can be set against a “normal” officer’s natural desire to have a reliable

\textsuperscript{273} “Report of the Torpedo Design Committee: Comparative Trials of Whitehead and RGF patterns,” 1894, TNA: PRO ADM 116/403.

\textsuperscript{274} Ibid.

\textsuperscript{275} See the various reports from the Torpedo Design Committee in TNA: PRO ADM 116/303 and ADM 116/403.

\textsuperscript{276} “Torpedo Design Committee Report,” December 1894, TNA: PRO ADM 116/403.
solution, and even more strongly against Fisher’s embrace of everything new without qualification. The system strongly encouraged a certain type of approach to problems—but an individual still had the latitude to impose his own vision.

Torpedoes, like guns, had important issues surrounding how they were mounted on ships. The Majestics’ torpedo tubes were submerged on the broadside, except one above water stern tube. Submerged tubes were not new, but they were not standard—the Royal Sovereigns mounted all above water tubes. Assistant Director of Ordnance for Torpedoes Jefferies suggested early in the design process that the Majestics and all future battleships should have the bulk of their tubes submerged, and further called for input from Captains of ships that did have them, and from the Admirals commanding in the Channel, the Mediterranean, and North America. The Board agreed, and the opinions of Captains at sea (and effectively, their torpedo officers) were solicited. The responses were universally positive, despite the limited experience with submerged tubes; all who replied endorsed them.²⁷⁷

This episode shows the importance of expert opinion, the consultative nature of decision making in the Royal Navy, and the authority of active senior officers. Jefferies was relatively junior, yet because of his expertise with torpedoes he was consulted in the design and his opinion taken seriously. Jefferies not only had a specific idea about equipment, but also thought that the best support for his view would come from those at sea using the system he promoted. Note, however, that opinions were solicited from Captains and Admirals, not the torpedo lieutenants who worked most closely with the

²⁷⁷ Ships Cover No. 136, Majestic Class NMM.
system. Undoubtedly, some of the senior officers consulted their experts – the torpedo lieutenants – before submitting their reports. Certainly, too, communication needed to take place within the chain of command, which made it inappropriate for the Board to consult junior officers directly. The Board, however, did not ask Captains and Admirals to consult their experts—it asked them for their assessment. The fact that the opinions of senior officers were sought and taken seriously indicates the collegial nature of decision making and reflects well on the Board members’ willingness to use opinions other than their own. The result was that submerged broadside torpedoes became part of the *Majestic* and were standard going forward.

Having accepted that the main guns for the *Royal Sovereigns* and *Hood* would be the older type, the Navy wished to be prepared and have the new main gun available for the next class of ship. While the *Royal Sovereigns* were still under construction, the Navy moved to begin the process of developing a new cordite-using gun. The delays due to difficulties with the War Office, documented above, led to the delay of the first two ships of the new class, the *Majestic* and the *Magnificent*, by a year.

The trouble did not end there, however. The first new gun, the 12-inch mark VIII, would not be ready until approximately August of 1893 at the earliest. The Navy, on recommendation of the Director-General of the Ordnance Factories, placed orders for ten, six of which had gone to the Royal Ordnance Factories and four were given to private industry in November of 1892 in order to have the guns ready by December of 1894.278

278 “Précis of Correspondence Relating to the Introduction of New Design 12-inch Wire Gun: Delays Caused by War Office,” April 1891 to August 1892, TNA: PRO ADM
The first gun was completed, and proofing tests began, in the summer of 1893. The cordite particle size was subsequently reduced and in April 1894, the Ordnance Committee reported that experiments indicated that expanding the loading chamber for the gun from 56.6 inches to 70 inches would produce less variation in muzzle velocity due to temperature.\textsuperscript{279} The Armstrong factory at Elswick, which was the private contractor for the guns, responded by indicating that the loading chamber could not be increased to over 60 inches without modification to the loading apparatus, which in turn meant changing the dimensions of the entire barbette.\textsuperscript{280}

This posed a significant quandary. There was no question of changing the mountings and barbettes of the \textit{Majestic} and \textit{Magnificent} at this point in their construction, but modifications were possible on future ships, if desired.\textsuperscript{281} Captain Domvile, the DNO, laid out the options in a memo. The guns could remain unchanged, with the consequent loss of about 50 feet per second muzzle velocity and the need to retain a slightly larger charge of cordite, which would increase wear on the gun. Alternatively, the loading chamber could be enlarged, which would optimize the ballistics but effectively require a new design of the gun mounting. If that option were

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\textsuperscript{279} Minute from DNO, April 1894, TNA: PRO ADM 256/30.

\textsuperscript{280} Minute from DNO to Director of Artillery, including copy of letter from Edward Lloyd, Elswick Works to the DNO, April 1894, TNA: PRO ADM 256/30.

\textsuperscript{281} Minute from DNO, April 1894, TNA: PRO ADM 256/30.
considered, the size of the gun could be increased to 40 caliber, with a growth in weight of about 80 tons.  

This latter option was the course recommended by the DNO. He argued that the experience of foreign navies demonstrated that 40 caliber was not excessive, as was feared at the time the 35 caliber gun had been adopted. The extra five calibers would increase the muzzle velocity by about 100 feet per second, from 2,400 to 2,500. He also contended, with concurrence from the Engineer-in-Chief, that it was early enough in the design and construction process that the augmented size and weight of the gun could be accommodated with only minor modifications.

DNC White wrote a thorough response. While favoring the adjustment in the 35 caliber gun, he opposed the increase caliber to 40. The weight, he wrote, would reduce stability unacceptably, unless armor protection of the barbettes was reduced. He also warned that a 40 caliber gun, even if it were based on the existing design that had been rejected, would still be a new gun and quite likely to run into the unforeseen delays that plagued main gun manufacture. He further noted that a contractor for the gun mounting was already asking for technical specifications and would need them soon to proceed in a timely fashion. He would, of course, defer to the Board as to whether a new gun design was worth the risk, but he definitely implied that they would be foolish to do so.

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282 Minute from DNO, April 1894, TNA: PRO ADM 256/30.

283 Minute from DNO, April 1894, TNA: PRO ADM 256/30.

284 Minute from DNC, April 1894, TNA: PRO ADM 256/30.
In response to this, DNO Domvile quickly withdrew his recommendation and supported White’s idea that the caliber be left unchanged. White, a civilian, trumped a naval officer. White’s expertise was certainly important, as was his ability to articulate his position and sway the opinions of others. White’s manner, however, was one of a man of authority, not that of a subordinate. His obsequious conclusion, formally submitting to authority, underscores the authority of his own earlier remarks because it was an obvious ploy to prevent offense to those who might regard his forcefulness as impertinent from a civilian. Domville’s retreat was also not one of a man faced with technical expertise that he had to acknowledge, but rather one of a man confronted by an equal who clearly had the better argument. White, while formally no more than a technical consultant, was really a member of the “college” and a decision maker in the Navy.

After Domville’s retreat, it took nine days, four days longer than it took White to draw up his response to Domville’s initial memorandum, for the First Naval Lord to reply with an approval, and the First Lord concurred the following day.\textsuperscript{285} The delay, while not that long, was typical though a bit of a puzzle given that the matter was of some urgency. It is possible, but unlikely, that First Naval Lord Admiral Richards was wrestling with the decision. More likely, either the memoranda from the DNO and DNC were making the rounds to the Board and any other interested parties and it took some time to reach Richards, or they sat unattended to on Richards’ desk while he was temporarily absent or while it worked its way to the top of a backlog of paperwork.

\textsuperscript{285} Minute from DNC, April 1894, TNA: PRO ADM 256/30.
Gunnery problems, particularly issues with the Ordnance Committee and the War Office chemists working for it, were still not all resolved. The Navy was having difficulties with flame coming out of the breaches of guns using cordite, when the guns were opened after firing. The Ordnance Committee acknowledged that this was indeed a problem and that it was, to the Committee’s knowledge, universal to smokeless powders. The Captain of the *Excellent*, as the head of the Royal Navy’s gunnery school and main gunnery experimental station and as a member of the “college” with an important voice on gunnery matters, complained that this significantly slowed the rate of fire and complicated other matters as well. He stated, perhaps a bit strongly, that cordite was scarcely worth the trouble it caused unless the problem could be fixed. The Ordnance Committee responded that the Navy was just going to have to make adjustments and deal with the problem as best it could.

This was entirely unhelpful, but it was a typical response to a Navy complaint about cordite. It was also very likely correct. However, instead of working with the Navy to convince it that this was a problem for which there was no immediate solution, the Committee and its War Office-employed chemical experts preferred to ignore the Navy’s concerns and treat them as petty complaints beneath notice. This would not be the last time the Committee treated Naval concerns this way.

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286 Letter from Captain of *Excellent* to Ordnance Committee, December 1895, TNA: PRO SUPP 6/108.

287 Reply to Captain of *Excellent* from Ordnance Committee, December 1895, TNA: PRO SUPP 6/108.
Protecting the Ship

Ships’ protection, particularly but not exclusively armor, was also improved, but also subject to some controversy, especially in the design of the Royal Sovereign class. The issue here was not the type or material composition of armor. Compound armor, a steel face bonded to iron backing, was the standard and was used for the bulk of the armor for the Royal Sovereigns, including the main waterline belt, where it was up to 18 inches thick.\textsuperscript{288} All-steel armor had recently been introduced and was used for certain secondary parts of the armor for the Royal Sovereigns, a first for ships of the Royal Navy.\textsuperscript{289} Steel armor was relatively new and not yet much more effective than compound armor.\textsuperscript{290} It would be consistent with the propensity of the Royal Navy to prefer the tried and true technology until the new had truly proven itself. In addition, there were questions about the ability of industry to provide the quantity and quality of steel armor needed for a larger number of ships.\textsuperscript{291} The Navy, having been burnt in previous decades waiting for new guns that could not be produced in quantity, made sure it avoided waiting for the best when the good was available for use immediately.

\textsuperscript{288} Parkes, pp. 355-356.

\textsuperscript{289} Conway’s, 1860-1905, p. 32.

\textsuperscript{290} Brown, Warrior to Dreadnought, p. 128.

The last three ships built in the class, the *Revenge*, *Resolution* and *Ramilles*, used Harvey steel for the upper belt.\(^{292}\) The Harvey process, invented in America, used a special water treatment to harden the face of the steel. If the use of compound armor as the main protection showed the preference of the Royal Navy for the proven over the new, the utilization of steel for non-main belt armor indicated a willingness to adapt, and adapt foreign methods, if needed.

What was contentious, as part of the form/size debate, was the arrangement of the armor, i.e. its thickness and what it covered. White’s design had a thick main waterline belt that ran between the fore and aft barbettes, with a thinner secondary belt above it. The ends were unarmored, so an armored bulkhead was used to cap the fore and aft ends of the belt. The barbettes got extensive protection, a protective deck was placed at the waterline, and the coal bunkers were arranged to supplement the armor.\(^{293}\) This layout provided good protection on the waterline for the ammunition and workings of the main gun, and for the boilers and engines. However, the upper deck had only the limited cover of the upper belt, and the fore and aft had no protection at all. This upset those like Reed, who, as noted in the previous chapter, supported very small, extremely heavily protected battleships.

The basic scheme of armor protection went forward with large, seagoing battleships. The *Majestics* carried a similar arrangement of armor. However, they had


\(^{293}\) Parkes, p. 385. The protective value of coal was well recognized already but in this case the coal bunkers were specifically designed as part of the armor protection system.
significant improvements in armor material. Harvey steel was used for the main belt, and its superiority over compound armor was such that the main belt was reduced to nine inches, without decreasing resistance to penetration.\textsuperscript{294} The weight saved was used to extend armor protection over more of the ship, including a longer and higher main belt armor. The barbette shields had a full ten inches of armor, making them as well protected as old style turrets, whose name they was soon appropriated.\textsuperscript{295}

Armor was not the only protection battleships had against attack. Torpedo nets were developed as the primary defense against torpedo attacks while the ship was still. Though the channel fleet once steamed for hours at 6 knots with its nets down, the nets were not meant for defense while moving. Early versions had them anchored to the hull at the level of the upper deck. However, this was above the level of the main deck secondary guns, and consequently ran the risk of fouling them. The nets on the \textit{Mars}, the seventh ship of the class, were lowered to the level of the main deck, below the guns, where this danger was eliminated. This placement was adopted for future ships and retrofitted to some older classes.\textsuperscript{296}

Ships at anchor, then, were well protected, but ships underway at normal speeds were not. Experiments on the old ironclad \textit{Resistance} in 1887, which had confirmed the efficacy of nets, showed that hulls could be very vulnerable to direct hits underwater. Explosions kept away from the hull did little damage, but explosions directly on the hull

\textsuperscript{294} Brown, \textit{Warrior to Dreadnought}, p. 150.

\textsuperscript{295} Parkes, pp. 381-382; \textit{Conway's, 1860-1905}, p. 34.

\textsuperscript{296} Parkes, p. 386.
were a different matter. Such explosions caused moderate, though survivable, damage in one trial but sank the ship in a second. The Navy, however, chose to emphasize the Resistance’s ability to stand off explosions and the trial that caused moderate damage, noting that “contemporary ships were well adapted to resist torpedo explosions.”

This was nonsense, as wartime experience with even newer ships demonstrated, and a major misjudgment.

There are two reasons for this failure: one systemic, the other personal. The systemic reason lies in the intersection of operational and strategic preferences of the Royal Navy’s officers, the results of exercises to test the effectiveness of torpedo-boats (the main weapon platform for torpedoes until submarines developed), and the development of countermeasures that addressed many of the dangers but also partly reflected the preferences of the officer corps. As previously noted, torpedoes worried many officers. While torpedoes launched from battleships during a fleet melee were a concern, a far larger one was the torpedo launched by the small, fast, and cheap torpedo-boat. The prime worry was that the torpedo-boat would be able to surprise battleships at anchor in harbor, especially at night. Defensive measures were needed to neutralize that threat. There were also those who thought that torpedo-boats would make an effective offensive weapon against fleets at sea. This was most famously part of the strategy of the French Jeune Ecole, which claimed that the torpedo-boat would drive the battleship from

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297 Brown, Warrior to Dreadnought, pp. 102-103.
the sea. This, of course, clashed directly with the ideas of the Royal Navy, which emphasized securing command of the sea using fleets of large, robust ships that utilized gunnery firepower as their offensive punch.

However, as it turned out the threat of offensive action by torpedo-boats, at least during the 1880s and 1890s, was negligible. French exercises in the 1880s showed that they were only able to operate effectively at sea in ideal weather conditions, and British exercises in the 1890s gave similar results. It was thus possible to dismiss torpedo-boats as a threat to fleets at sea. However, some exercises, particularly those by the Royal Navy in 1890, showed that torpedo-boats could indeed be effective in “narrow seas,” that is, in areas close or relatively close to shore. “Narrow seas” minimized the lack of seaworthiness of torpedo-boats, provided hiding places from which to ambush larger vessels, and limited the room larger fleets had to evade and maneuver.

The Royal Navy began to invest significant resources to develop countermeasures to torpedo-boat attacks. Torpedo nets had already demonstrated their effectiveness, and development work continued. Searchlights, discussed below, were also subject to continuous testing and development. Anti-torpedo-boat armament (machine guns; 3, 6 and 12 pound cannons; and even the central secondary 6 inch QF guns could be used for.


299 Cowpe, pp. 31-35.
that purpose) was already a standard feature on large ships, and testing for the best mix of armament and technique continued. Further, large sums were spent to protect harbors on the English Channel, to guard against the most feared scenario: a surprise attack at anchor. Finally, the Navy chose to develop ships designed to counter torpedo-boats by attacking them—the torpedo-boat destroyer. These vessels were the brainchild of “Jacky” Fisher during his time as Controller. They were to patrol and attack active torpedo-boats and blockade those that were waiting in sheltered anchorages in an attempt to ambush the larger vessels of the Royal Navy. Despite serious weaknesses, most importantly the fact that early torpedo-boat destroyers were no larger and thus no more seaworthy than torpedo-boats, they did have some success in exercises and the Royal Navy was well pleased with their effectiveness.\textsuperscript{300} They too would be subject to further development and significant improvement by World War I.\textsuperscript{301}

However, the situation was not quite so cut and dried. Alan Cowpe’s investigation of the Royal Navy’s attitude toward torpedoes reveals that the prevailing mindset of the Navy was to belittle their performance and potential as a serious weapon for anything other than coastal or harbor defense or a surprise attack under ideal circumstances—which generally meant at night against a ship at anchor in harbor. Cowpe contends, quite correctly for the most part, that many officers saw torpedoes as a threat to the traditional naval doctrine based on fleets of large ships pursuing an offensive

\textsuperscript{300}Cowpe, pp. 34-36.

\textsuperscript{301}For the early history of destroyers, see David Lyon, \textit{The First Destroyers} (Annapolis: Naval Institute Press, 1996) and for details on British destroyer designs through the turn of the century see \textit{Conway’s, 1860-1905}, pp. 86, 90-100.
strategy. As a result, many focused on what torpedo-boats proved they could not do in the exercises, which was to attack aggressively on the open seas. This had the effect of defending the methods and mindset of the Royal Navy, which was the intent, but it also obscured thinking about the possible need for defending ships against torpedo attacks except under certain, limited conditions. Torpedo nets, anti-torpedo-boat armament, and harbor defense addressed most of those circumstances. Outside of those conditions, offensive patrolling by torpedo-boat destroyers and the anti-torpedo-boat armament of battleships would, so it was thought, prevent torpedo-boats from getting close enough to engage with a reasonable chance of hitting and so cover the remaining circumstances. A few officers, like Fisher, had some idea that technical improvements would make torpedoes far more dangerous in the future. Most, however, due to the limits of their preconceptions, were satisfied that the threat was met.

The second reason the Royal Navy ignored developing protective measures against torpedoes had less to do with institutional prejudices but rather with the actions, or lack of action, of a single individual—William White, DNC. White, who exercised an important leadership role in designing the Navy’s battleships, failed to lead the Navy with regards to torpedo protection. As a quick note here, there is a distinction being made between defense and protection. Torpedo defense includes various measures, both active and passive and both on the part of the ship and on the part of the supporting infrastructure. Everything discussed above falls into that category. Protection, as it is being used here, includes items that prevent or negate damage once the torpedo has hit. So, armor constitutes protection against gunfire—it does nothing to prevent the ship from
being hit, but prevents (or minimizes) the damage to the ship once hit. The Royal Navy invested in torpedo defense but not, until after World War I had begun, in torpedo protection. White neglected protection against torpedoes and also the investigation of protection that might have yielded information about successful techniques.

The primary issue was one of attitude. White’s predecessor as DNC, Nathanial Barnaby, did not believe that it was possible to protect ships completely. White absorbed this attitude from a man he worked closely with for thirteen years. As shown in the form/size debates, White was not focused on armor protection. He was willing to trade protection to gain other favorable ship characteristics. As long as the ship could still function offensively (keep afloat, maneuver, and fight), damage sustained was acceptable as inevitable. This is underlined in his defense of the Admiral class of battleships, built in the early 1880s. Though they were Barnaby’s ships, as Barnaby’s assistant White was very involved in their design. The Admirals were much criticized for having unprotected ends, and many speculated that this would disable the ships if they flooded as the result of damage. When one of the ships had its forward compartments flooded as a test, the ship was still capable of continued operation—it was not in danger of capsizing and could still maneuver and fight. White was sufficiently satisfied, and he designed the armor in the Royal Sovereigns similarly.\(^3\)

\(^3\) Cowpe, p. 26.

White also followed the lead of the naval officers he was surrounded with in regard to the idea that ships engaged in action would risk and take damage in order to deal damaging blows to the enemy themselves. Protection was useful but too much showed a lack of aggressive spirit. White became a respected decision maker for the Navy, and not just a technical consultant, in large part by not challenging the expertise of officers or their perception that it was within their prerogative to decide what was needed on warships. He might argue forcefully for his opinion, as he did against Domvile on changing the size of the guns, but he at least always appeared ready to defer to serving officers. He might even go so far as to contradict the fundamental assumptions of what a ship needed to be, as he did with Admiral Hood during the form/size debates. He only did so, however, when he had a substantial part of naval opinion behind him. As stated before, White would only lead where the Navy was ready to go. Protection was not the central concern of the officers for their ships—and likewise it was not White’s.

White’s neglectful attitude was reinforced by the technical difficulty of the problem. It did not appear to be possible to provide protection against torpedo attack without investing so much weight in armor below the water line that the ship would sacrifice more speed, endurance, and firepower than White, or the vast majority of officers, were willing to concede. Former DNC Edward Reed (Barnaby’s predecessor) proposed a highly compartmentalized double hull carrying four inches of armor on the inner hull, for example, but the Navy never took this idea seriously because the armor

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304 See Admiral Sir Reginald Custance, *Lissa, the Yalu, and the Capital Ship* (Edinburgh: William Blackwood and Sons, 1910) for an example of the advocacy of “offensive spirit.”
weighed so much. The French tested a system in 1894 similar to Reed’s proposal, using one and a half inches of armor instead of four. It failed dismally, as a huge hole was blown in both inner and outer hulls.\textsuperscript{305} Some armor, it appeared, was not enough.

Not that the Navy, at White’s direction or otherwise, put much effort into trying to do better. Live fire tests against armor were regularly carried out to test armor, guns, propellant powder, fuses, and shells, but the gap between trials of protective schemes against torpedoes, aside from tests of nets, lasted seventeen years. In 1887 the Navy experimented with underwater explosions as part of the \textit{Resistance} experiments, but did not follow these up until 1904, after White had retired. At that time an underwater explosion was used against the \textit{Bellisle}. The \textit{Bellisle} had been fitted with a layer of cellulose attached to the outside of the hull, which was supposed to expand when wet and help fill any holes in the hull, and with bunkers filled with coal between the outer hull and inner skin. While the inner skin was not broken, the cellulose was blown apart and the outer hull was badly breached. Full coal bunkers, an effective secondary armor against gunfire, proved ineffective against an underwater explosion against the hull. The shock of the explosion emptied the bunker and sprayed coal all over the ship. Protective screens were added to the \textit{Dreadnought} to protect against this, but there was no other action taken to investigate other methods of torpedo protection.\textsuperscript{306}

\textsuperscript{305} Parkes, pp. 326-327, 412.

\textsuperscript{306} Parkes pp. 413-414.
Electrification and the Vernon

The Royal Navy was also beginning to make significant advances in the use of electricity. The Royal Navy had experimented with its first electrical device, a searchlight, aboard ship in 1874. Significantly, it was a response to another new technology, the torpedo, as it was designed to search for and spot torpedo-boats attempting to sneak up at night.\footnote{Brown, \textit{Warrior to Dreadnought}, p. 66.} By the end of the 1870s the Navy had begun the process of making electricity a permanent feature on its ships; the \textit{Edinburgh}, laid in 1879, was designed with searchlights\footnote{Brown, \textit{Warrior to Dreadnought}, p. 80.} and the first generator was installed on the \textit{Inflexible} before its commissioning in 1881, also for searchlights.\footnote{Denis Griffiths, “Warship Machinery,” in \textit{Steam, Steel and Shellfire, the Steam Warship, 1815-1905}, Robert Gardiner, ed., (Edison, NJ: Chartwell Books Inc., 2001, p. 176.} By the time of the Naval Defense Act, electricity had established itself aboard Royal Navy warships. In addition to lighting, batteries were introduced and firing mechanisms for guns had been electrified on large ships.\footnote{Reports on various tests on searchlights from “The Annual Report of the Torpedo School,” TNA: PRO ADM 189/9.}

In 1881 the \textit{HMS Vernon}, the Royal Navy’s school for training officers and ratings in torpedo use and maintenance, also began its annual reports as an experimental facility. Together with torpedoes and mines, the \textit{Vernon} was also the center of the Royal
Navy’s work with electricity. Why the Vernon was placed in charge of electrical matters is unclear, but it was probably related to fact that the experts at the school, due to their work with torpedoes and mines, were regarded as the “techies” of the Navy. In any case, the school did experimental work with electrical devices, tested devices of private firms that the Navy was considering using, managed and reported on “field tests” of devices on active ships, and trained officers and men in the use and maintenance of electrical equipment. While the Vernon was a school first and experimental work was sometimes neglected due to inadequate personnel, it was an important link in the Royal Navy’s extensive scheme of experimentation with new technology. Starting with the Vernon’s first annual report, when it recommended incandescent lights over arc-lights, it was the prime resource for determining what electrical technology was used by the Royal Navy before World War I.

The Royal Navy was very close to the “cutting edge” of electrical technology. Electricity and electrical motors were just emerging from experimental use into the commercial realm in the 1870s. Illumination, the area where electricity was first introduced into the Royal Navy, finally began to emerge as viable. An arc-lamp was

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313 See “The Annual Report of the Torpedo School,” TNA: PRO ADM 189/1 to ADM 18/34. School not only conducted trials and experiments, it also coordinated and managed sea trials of various items of equipment. The recommendations of the school on electrical equipment were usually accepted.
installed in Big Ben in 1873, only 10 years after the first commercial applications in French lighthouses. An arc-lamp produces electricity by arcing an electrical current through the air between two closely placed but separated carbon rods. It produced a bright light, but the carbon rods wore out very quickly and needed to be replaced often.

The first commercial public lighting system was installed in Public Square in Cleveland in 1879, the same year Thomas Edison would produce his first long lasting incandescent light. Edison had solved the problem of making the filament, through which a current was run to produce light, long enough lasting to be more economical than the arc-light, which it ultimately replaced for most functions. The first public demonstration of an electric motor driven by an electric generator occurred in 1873 in Vienna, and the first industrial use of an electric motor was running a conveyer belt in France in 1880.

Commercial production of electricity began in 1879 with a power generating station in San Francisco, and Edison’s famous Pearl Street Station in New York City opened in 1882. The Royal Navy, then, employed electricity in ways that were as advanced as anyone in the world outside a laboratory in the 1870s and 1880s—and would continue to do so into the 1890s.\footnote{Malcolm MacLaren, \textit{The Rise of the Electrical Industry During the Nineteenth Century}, (Princeton: Princeton University Press, 1943), pp. 65-131.}

The Vernon’s work with electricity was focused on finding suitable equipment for naval use, with secondary objectives of optimizing the use of electricity, coordinating shipboard trials of electrical equipment, and spreading innovation and best practice throughout the fleet. The technology was still primitive. Such elementary items as proper
wiring of circuitry, standardization of on/off switch directions (left was off), backup systems both for the generation and distribution of power, safety cut outs, and override cut outs were all items that required the *Vernon*’s attention.\(^3\) The staff of the *Vernon*, consisting of officers and non-commissioned officers trained by the Navy in practical electrical engineering, spent most of their time experimenting with components and working to design systems that were more reliable, easy to maintain and, especially, more robust.

This was a significant issue for the Navy, as its equipment had to function in a much harsher environment than almost any civilian gear. Often this precluded the use of “off the shelf” civilian components (which themselves were still rare, but becoming more common as electrification spread) and required the Navy to build its own equipment from scratch.\(^3\) Heavy use was made of feedback from active duty ships, as it was correctly thought that only actual service could properly stress test components and systems. Sea trials generally determined what equipment was adopted and led to steady improvements in electrical systems.

For example, the *Vernon* probably spent more time on lighting issues than anything else while the ships from the Naval Defense Act and the Spencer Program were under construction, roughly 1889-1896. Internal lighting was a relatively minor part of


\(^3\) For example, see the various reports new equipment designed by the school, “The Annual Report of the Torpedo School,” 1889-1890, TNA: PRO ADM 189/9 and ADM 189/10; Other examples can be found in reports from other years.
this work, and the focus was primarily on finding or creating suitably robust components. Searchlights and signaling lights consumed much more time and energy.  

Searchlights, which had been the first electrical devices on Royal Navy ships, were still far from perfected. Lamps were an issue, but even greater issues were mountings, wiring, weight, location, and methods of use. Work on improving searchlights, either through experiments at the Vernon or sea trials of new equipment, was constant.  

Signaling lights advanced from discussion of the possibilities to sea trials of various types. Internally, the search continued for suitably robust light bulbs and included initial discussions about flashlights.  

Another issue the Vernon dealt with was the introduction of electrical machinery. Most of the powered auxiliary machinery on Royal Naval vessels was steam driven, either directly or through hydraulic systems. The potential of electric motors for many of these uses was obvious, and electric motors soon replaced steam driven ones for many

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318 ibid.


basic functions, such as electric fans for ventilation. Other applications were soon under trial. The Barfleur, a second-class battleship provided under the Naval Defense Act, hosted tests on some of the earliest uses of electrical power for auxiliary machinery. An electric motor for elevating its main guns was installed in 1893. The trials revealed a number of minor, but fixable, problems with the system, and the overall report was positive, noting that in comparison to hand elevating gear the “time saving when using the motors is most marked.” The officers liked the system, always an important point, and the Dockyards and Engineer in Chief agreed that it was suitable. An electric driven motor for an ammunition hoist was also installed and proved quite successful as well.

These systems were rolled out and made standard for two Majestics and the Renown, meaning they were in use as standard items of equipment in the battleships of the Royal Navy by the mid to late 1890s, about the same time that steam locomotives were being replaced by electric trains in large cities.

The pace of adoption of electrical equipment was slow and deliberate. The technology was still very new, and many basic issues ranging from circuits and control systems, components, and wiring to safety issues (water and electricity mix badly) had to

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be determined from scratch. The complete system of electrical use still needed
development. Electricity was still what Walter Vinceti and Thomas Hughes, for slightly
different reasons, called “radical” technology. Electricity, used for lighting, motors, and
related functions, was a departure from older, existing systems. It was not an incremental
advance but rather one demanding the creation of an entirely new system.\footnote{Thomas Hughes, “The Evolution of Large Technological Systems,” in Wiebe Bijker, Thomas Hughes and Trevor Pinch, eds., \textit{The Social Construction of Technological Systems} (Cambridge, MA: The MIT Press, 1987), p. 57; Walter Vincenti, \textit{What Engineers Know and How they Know It} (Baltimore: Johns Hopkins University Press, 1990), p. 8.} In addition, Hughes makes the point that radical inventions still require a great deal of development to work properly.\footnote{Hughes, “Evolution”, p. 59-60.} The Navy, while interested enough to engage in tests and trials, wanted developed, reliable systems for its warships. As development of electrical systems progressed, the Navy adopted more electrical technology for its ships.

The Navy also was in no hurry. Much of the work that could be done electrically
was already accomplished, reliably and effectively, by steam. While the Navy welcomed
technical improvements, there was little perceived need to introduce a new and untried
system to replace systems that already performed to the satisfaction of Naval officers and
engineers. There was generally no perception of the failure of old systems to drive the
search for a radical solution.\footnote{Edward Constant, “The Social Locus of Technological Practice: Community, System, or Organization,” in Wiebe Bijker, Thomas Hughes and Trevor Pinch, eds., \textit{The Social Construction of Technological Systems} (Cambridge, MA: The MIT Press, 1987), p. 225.} This was further demonstrated by the functions for electricity that were most rapidly adopted: lighting (especially search lights) and
communications (discussed below). Searchlights were considered a requirement for torpedo-boat and the reason electricity was introduced on Royal Naval warships. Once electric lights had demonstrated their efficacy, they were rapidly put to use for internal lighting, replacing potentially dangerous open flames.

Finally, there were institutional cultural obstacles to the adoption of electricity. Steam technology was well known and highly understood in addition to being effective. The Navy had a great store of institutional engineering knowledge about steam engines, and could draw on extensive knowledge and experience from many experts in the civilian economy, where steam power was widely used. The Navy was comfortable with steam and knew how to solve the problems of steam engineering—and when it could not, it knew where to find help. It did not have the same institutional background with the new technology of electricity, nor did the wider society contain a large amount of expert knowledge that it could draw upon. There was no reason for the Navy to embrace a radical new system when it already had so much invested in the old one.\textsuperscript{330}

Another facet of the institutional cultural restraints on the Navy was what Arnold Pacey calls “the culture of expertise.” Pacey argues that this culture tends to focus minds narrowly on a particular set of approaches to an issue.\textsuperscript{331} Naval officers and engineers were trained in steam, and thought of solving engineering problems in terms of improvements in steam technology. While this meant that steam engineering was

\textsuperscript{330} Hughes, “Evolution,” pp. 57-58

\textsuperscript{331} Pacey, p. 35-54.
developed to a very high state of sophistication, it also meant that naval personnel were not thinking in terms of alternatives.

Still, electrical technology spread in the Royal Navy. Reliability and robustness came slowly. Electrical gear was often heavier and sometimes bulkier than the steam gear it would have replaced, a very significant problem on board ship. While it took time for electrical equipment and systems to demonstrate superiority over older steam systems, when they did they were accepted and integrated into the larger ship system. By 1896, electrical generators were directed to be placed under the armored deck that covered the boilers, engines, and magazines.\(^{332}\) Electricity had become important; generators were worth protecting.

Communication technology intersected with electrical technology by the 1890s. Communication on board ship in 1889 consisted of runners, voice pipes, and some basic telemotors and ship’s telegraphs.\(^{333}\) Communications channels radiating outward from the bridge were dominant. This was moderately effective, though the sound coming


\(^{333}\) Telemotors are hydraulic pumps that push and pull hydraulic cylinders connected by hydraulic lines to a corresponding device elsewhere, to cause a corresponding change in that device or move some other mechanism. Their most prominent use was for steering (e.g. moving the rudder from the Bridge). Ship’s telegraphs were two identical devices connected by wires that physically moved some portion of their corresponding device. Their most prominent use was for transmitting orders and acknowledgements for engine speed (e.g. full ahead, half ahead, half astern, full astern, standby) from the Bridge to the Engine room.
through voice pipes could be overwhelmed by ambient noise, particularly in the engine room. Electric communications, in the form of the telephone, offered an alternative.

Telephone technology was somewhat more advanced than general electrical technology: general components had been built, but they were still undergoing significant development. The first trials were on the Majestic in 1895. They were successful enough that further tests were carried out by the Excellent in 1896. The Excellent reported that the telephone was slightly better than voice pipes. The report also indicated that the telephone was expected to surpass the voice tube soon. One significant drawback compared to voice tubes was that a line could as yet only carry a single signal. This required a switchboard and an operator, which meant communication with the bridge was indirect. On the other hand, noted the Excellent, the system of voice pipes produced “babble” on the bridge. Indirect communications was rated as more acceptable.

Naval officers were interested in improving communications because the ships had become large enough that it was difficult for the Captain to control its remote points. Telephone-based communications seemed to be a way to solve the difficulty,

334 Ships Cover No. 146, Canopus class, NMM, for effectiveness of voice pipe, find other citation


336 Ships Cover, No. 146, Canopus class, NMM.

337 Ships Cover, No. 146, Canopus class, NMM.

338 Letter from Bridge to Custance, August 14, 1891, BRI 18/4, NMM.
and their potential was clearly recognized. However, like most other new technology, the Navy was cautious and adopted telephones gradually. As in other circumstances, the primary issues were the need for the new technology to be clearly better than the old, robustness, and reliability. The communications channel needed to carry information effectively and be easy to use, while simultaneously being able to withstand the rigors of the sea and the abuse of combat but still continue working. Telephone communication promised this, and spread.

Conclusion

Technological change brought difficulties to the British when they began to build up their navy with the Naval Defense Act of 1889 and the Spencer Program of 1893. Gunnery systems were in the process of undergoing major change as nitrocellulose powder and quick-firing secondary armament would soon make older guns obsolete. However, like most new technology, smokeless powder and the new guns to optimize its use, quick-firing guns, and new torpedo systems did not come into being fully formed and operational. There were delays and difficulties as unexpected problems became manifest and needed to be dealt with. The same holds true for the various components needed to generate and use electricity effectively. New technology in these areas was promising but often still in need of development.

This placed the leadership college of the Royal Navy in a difficult position. Once new equipment was “better” than the old was they wanted it, knowing that they would
eventually need it. The Navy, however, was building ships now and not when the technological bugs had been worked out of the new systems or the Ordnance establishment got around to doing the necessary experimental and development work. They had to make the difficult decision between accepting delay (or the significant risk of delay) and accepting older but known and reliable technology. Where the risk to naval readiness was high, they chose to work with what was available, rather than attempt to push forward. On the surface, this might appear to be a reluctance to embrace new technology but what was really happening was that the leadership of the Navy was deciding in favor of readiness, predictability, and reliability over the untried. Given that they probably overestimated the threat represented by the combined Franco-Russian fleets, this may not have been necessary. However, that is only clear in hindsight, and their decision is reasonable for the information available at the time. The exception to this was with torpedoes, where Wilson was paralyzed seeking perfection.

Putting older technology into operation also did not mean that the Navy was not putting effort into developing promising new technology. It usually pushed the Ordnance establishment and the War Office as hard as it could to get them to develop guns and powder fully into operational usefulness. Occasionally they failed to pressure the War Office, but this is more a reflection of the administrative workload imposed on Board members with little administrative support. The *Vernon* put forth steady effort in developing electrical systems, and experimental trials were common. Of course, the *Vernon* did not always have the personnel available to devote time to these efforts, which were secondary to its function as a training establishment, but this too was less a
reflection of lack of desire and more a reflection of the press of other priorities surrounding current readiness. The Navy needed trained personnel to service current equipment, and since the best equipment in the world would be of little use without trained personnel this approach would ensure that the Navy had skilled officers and ratings as advances were introduced.

The pattern of accepting established technology and at the same time developing new technology was not so much a policy as a series of ad hoc decisions that tended in the same direction. Of course, it is human nature to prefer the known to the unknown generally, and the officers of the Royal Navy could be criticized for not rising above this. However, the decision to prefer the known was the result of an unarticulated but commonly held set of beliefs held by most of those in the “leadership college” of the Royal Navy—that reliability, predictability, and readiness were more important than being on the cutting edge. Given that the Majestics were considered the finest ships in the world when they were commissioned, this was a wholly defensible decision.
Chapter 4:
Steady Growth, Continued Improvements

Introduction

Unfortunately for Great Britain, the Naval Defense Act and the Spencer Program did not provide the deterrent value that First Lord Hamilton had hoped, but rather kicked off a naval arms race, as Prime Minister Lord Salisbury had predicted. The Anglo-German naval race in the decade before World War I is far better known, but the British were engaged in a different naval arms race in the 1890s—one with France and Russia. In addition, the German, Japanese, and American fleets grew, and while none were regarded as a threat individually, they inspired British concern about having the fleet strength available to deal decisively with any threat they might pose while still maintaining sufficient available force to handle a Franco-Russian attack. The Royal Navy laid down at least one new group of battleships every year from 1896 to 1901, and those ships entered service regularly from late 1899 until spring 1904. Throughout, the Navy used the pattern established with the Royal Sovereign and Majestic classes, both in terms of the physical pattern of the ship—its size and shape, basic equipment, and operational role, with adaptations for specific functions—as well as the decision making process that established those parameters and the deliberate method of adopting and adapting new technology.
The Royal Navy did not just build new copies of older designs, but continued the process of adopting and adapting new technology. While there were no radical changes to battleships during this period, there was a steady stream of improvements to armor protection, guns, propulsion, and electrical power. The leadership of the Navy was most assuredly not old sailing-era admirals who ignored new technology. They were men accustomed to change and to analyzing whether new technology was useful to the Navy. The Navy was willing, even enthusiastic, to adopt new technology when it gave them “better” ships.

The process remained a smoothly operating system. William White continued to be a force, his credibility and leadership leading the Navy forward in a number of important ways. The Board continued to work together smoothly. The earlier debates about the form and size of British battleships had subsided and the result was that British battleships were large, individually powerful, seagoing, and highly mobile with great endurance, moderate protection, and an emphasis on offensive capability. They were all about the same size, about 430 feet long with a 75 foot beam, and ranged from 13,200 tons to 14,700 tons load draught and up to another 1,000 tons at deep draught.339

One issue that comes to the forefront during this period is the Royal Navy’s preference for and reliance on quantitative information. Trials and tests, particularly comparative trials and tests, are the center of the processes of evaluating equipment. This

is not a new development of the time—look back to the comparative trials of the various types of range finders begun in the early 1890s, for example—but it is very obvious in the developments in the later 1890s. New armor and new boilers were adopted for the Canopus class after testing showed superior performance over older models. The best example, however, comes from the work being done at the Naval Experimental Station at Haslar, run by William and Edmond Froude. Initially founded in the 1860s, its work on hull and propeller design made it one of the premier naval and maritime testing stations in the world for decades. By the late 1890s, using the data produced by Haslar’s model trials was second nature to the Navy: their experimental results were gospel. The testing at Haslar was itself a new technology and the not so reactionary leadership of the Navy embraced it.

While most of the new developments during the late 1890s were incremental improvements to older basic technologies, work also began on what would eventually be a radical technological departure: wireless transmission (W/T) or radio. The Navy looked upon W/T with great interest, following private developments closely from its earliest invention in the late 1890s. The Navy’s approach to W/T was in many ways typical of its approach to new technology in general. Once it reached a certain level of development, the Navy began to experiment with it, adapting it to fit its own needs. The Navy also began to study seriously how such technology would be used and what implications such use would have on naval operations in general. From its earliest exercises experimenting with W/T the leadership of the Navy was aware that W/T signals were far more vulnerable to being intercepted than flag signals or dispatches, and took
active care to promote secure, coded transmissions. This last point is a far cry from an anti-technological naval leadership that refused to acknowledge new technology until forced to, and instead shows active minds considering how a new tool could be used effectively. It also very likely points to the roots of Britain’s widely recognized skill in signals intelligence and counter-intelligence, as displayed in both World Wars.

Thus the 1890s, far from being a period when reactionary officers attempted to hinder the introduction of new technology and equipment, was instead a period of deliberate but substantial technological improvement and change. Change was not embraced for change’s sake, to be sure, and the Navy’s leadership remained conservative and deliberate in their acceptance of new things—they did, after all, have enormous responsibilities and did not need to take large risks to maintain the superiority of the Royal Navy. The Navy’s leadership, trained in the hard school of ships at sea, was realistic enough to accept quantitative data, unequivocally successful trials, and demonstrations of new equipment and technology, and while few were prepared by temperament to embrace change, the vast majority accepted it as needed to fulfill their responsibilities.

The Canopus Class: New Armor, New Boilers

The Canopus class, the first to follow the Majestic class, was intended to address the changing situation in the Far East. The Japanese victory over China in the Sino-Japanese war of 1894-1895 turned British attention to the region. Competition for the Chinese market appeared to be heating up, and the growth of French, Russian, and Japanese naval
power in the region put pressure on Great Britain to keep up. This the British did, doubling the size of the China squadron in response to similar growth of the French and Russian squadrons. Relations with Japan were good, as Japanese and British interests were similar: contain Russian expansion. However, there was no cooperation between them, and Japanese battleships building in British yards were considered superior to the Second Class vessels, the *Imperieuse* (an older vessel, laid down in 1881 and completed in 1886), *Centurion*, and *Renown* classes that were normally part of the China squadron. In these circumstances, the Board felt the need for new, modern ships for the Far East.

Again, the question became: what kind of ships? Cost concerns were important; despite steady political support, the Navy did not have a blank check. Boards were always concerned with costs. This applied not just to the First Lord, who was a politician and responsible for advancing naval budgetary demands to the Cabinet and defending them before Parliament, but also to the naval members of the Board. In addition, the ship had to fit through the relatively shallow Suez Canal, something the *Majestics* and *Royal Sovereigns* could not do. These pressing factors kept the ship smaller. White expressed concern about the quality of new Japanese builds in a lengthy memo and the Board concurred, which indicated the need for larger ships. The situation could have reopened the debate, yet again, on the proper type of battleship for the Royal Navy.

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340 Marder, *Anatomy*, pp. 238-240

341 Ships Cover, Number 146, *Canopus* Class, National Maritime Museum, Greenwich.

342 Ships Cover, Number 146, *Canopus* Class, NMM
It did not, for a number of important reasons. “Big battleship” proponents had won both previous rounds of debate decisively, and while there were still important officers left who supported the idea of smaller ships, they were in a distinct minority. White had established his credibility as a designer with two successful classes of battleship, not to mention the cruisers and other smaller ships in service, and with his articulate stance in favor of larger ships. He was opposed to anything that could have been considered inferior to any other ship afloat, and his arguments could carry opinion in the Navy. Likewise, the First Sea Lord Admiral Sir Fredrick Richards was also a strong proponent of large battleships.

Richards saw the need first in terms of readiness. The Fleet must be ready to fight at all times:

Supposing the enemy to be France, the second great naval Power, the duties above sketched would require our fleet to be constantly ready, always with steam at command, while the French fleet, stationed on interior lines and in impregnable harbours, [sic] need not so much as light a fire until a favorable opportunity should present itself for action.

All this means staying power, and staying power means coal. Only a large ship could carry the coal needed for instant readiness and still possess the required firepower, speed, and protection, according to Richards. He also wanted ships

343 Letters from Reginald Custance to Cyprian Bridge, Bridge papers, NMM BRI 15, pt. 2, 3.

344 Minute by Admiral Frederick Richards, Senior Naval Lord, October 31, 1895, TNA: PRO CAB 1/2/14.

345 Minute by Admiral Frederick Richards, Senior Naval Lord, October 31, 1895, TNA: PRO CAB 1/2/14.
that could maintain speed in poor seas, which also required a larger ship, and he expressed doubt that smaller ships could be combined as a combat force as effectively as their advocates contended.  

Political circumstances, including renewed diplomatic crises, expansive foreign naval plans, and a Conservative government committed to a naval buildup, accelerated the timetable of the Canopus program: all five ships were laid in one year instead of two. Yet there seems to have been some hesitation at the cost. The new building program, when introduced in March of 1896, called for £7.8 million for new construction (including smaller ships), an increase of over £2 million over the previous year. This must have given the government pause, because several documents giving the Admiralty’s reasoning for the large size of the Canopus class were circulated to the cabinet in December of 1895. They included a lengthy piece written by White during

346 Minute by Admiral Frederick Richards, Senior Naval Lord, October 31, 1895, TNA: PRO CAB 1/2/14.

347 Marder, Anatomy, pp. 241-273.

348 Marder, Anatomy, p. 263; David K. Brown, Warrior to Dreadnought, Warship Development, 1860-1905 (London: Caxton Editions, 2003), p. 205 gives £9.7 million, up from £7.9 million, but this is exclusively the construction budget and does not include armament, which is another category; Jon Sumida, In Defense of Naval Supremacy (Boston: Unwin Hyman, 1989), Table 6, reports that £13.2 million was budgeted, up from £10.9 million, but this includes spending for certain types of maintenance and repairs. In Table 8 Sumida reports construction spending of £7.6 million up from £6.2 million, but this does not include the cost of armament. In addition, not all money authorized was spent during the late 1890s, for reasons including labor problems and construction delays due to a shortage of shipbuilding capacity, Sumida, pp 17-18. No matter which figures are used, it amounts to a significant increase in spending.

349 Minute by William White, DNC, November 20, 1892, Minute by Admiral Frederick Richards, Senior Naval Lord, October 31, 1895, Extract from a Report by Sir William
the debate over the size of the *Majestics* in 1892, a memo by Admiral Richards (quoted above) written in the fall of 1895, and an extract of another piece by White justifying the size of the *Majestics*, written in 1893. While cost might not have been the issue, there seems to have been little of the agitation for smaller ships that surrounded the designs of the *Royal Sovereigns* and the *Majestics*.

The cost of laying down five new ships in one year right on the heels of two programs totaling twenty battleships, some of which were still under construction, put some strain on state finances, which the government wished to ease. The political atmosphere of the time demanded balanced budgets. Tax revenue was increasing and extra revenue was usually used to pay down the debt. Higher naval spending precluded such an action.\textsuperscript{350} The Board, led by First Lord Goshen, favored the full sized *Canopus*, and the government took its advice and moved ahead. Public and parliamentary support for a strong fleet was running high, and there were no political complications like those that delayed the full Spencer program.\textsuperscript{351}

The *Canopus* class was to be full sized, but it still needed to fit through the Suez Canal, which had a maximum depth of 25 feet, 4 inches until 1902. The *Majestics* had a draft of 27 feet. White wished to lengthen the ship, which would have reduced the draft,


\textsuperscript{351} Marder, *Anatomy*, pp. 263-264.
but the Board refused.\textsuperscript{352} Instead, the hull dimensions of the \textit{Majestics} were retained and the weight was reduced by 1500 tons. Most of this was accounted for by reducing the thickness of the main belt of armor to six inches. The ships still had a draft of some 26 feet, but they could traverse the canal “light.”\textsuperscript{353}

The reduction in armor was not as significant as just counting inches made it appear, thanks to the introduction of Krupp cemented process steel, which was developed in Germany. This was similar to Harvey steel, with a slightly different alloy composition and a somewhat different treatment process for the front face. White saw a demonstration in August of 1896, shortly after it was introduced, and immediately convinced the Board to adopt it.\textsuperscript{354} His credibility, combined with the results of the tests he witnessed and the need to minimize weight, convinced the Board to change armor material for the second time in five years and accept considerable extra expense while doing so.\textsuperscript{355} Six inches of Krupp was the equivalent to more than seven and a half inches of Harvey armor.\textsuperscript{356} This was less protection than the \textit{Majestic} class’ nine inches, but not as much less as it seemed. Like Harvey armor, Krupp was not developed in Britain—though British armor makers licensed the technique and began to manufacture it—and like Harvey armor, the Royal Navy was very quick to change to it. They were among the

\textsuperscript{352} \textit{Canopus} Class, Number 146, NMM

\textsuperscript{353} That is, with water tanks run down, coal stores removed, etc.

\textsuperscript{354} Minute from William White, August 1896, TNA: PRO ADM 256/33.

\textsuperscript{355} Brown, \textit{Warrior to Dreadnought}, p. 146.

\textsuperscript{356} Parkes, p. 396.
first to adopt Krupp cemented steel as the standard armor, and every other important navy was using it within a few years. The leadership of the Navy, led by White to be sure, was once again willing to adopt new technology quickly and decisively once the technology demonstrated its superiority. Unlike Harvey process armor, Krupp technology remained the standard, albeit with incremental improvements, through World War II.

White also managed to expand the area of the side protected by the main belt, which he felt was as important, if not more so, than the maximum thickness, and a thin belt was extended to the bow.\textsuperscript{357} A special armored deck was added over the upper deck gun casements due to reports that the French were using howitzers.\textsuperscript{358} Portions of the deck were also reinforced to hold howitzers, should the French experiment be successful.\textsuperscript{359} The French experiment failed, but the adaptation of the armored deck and preparations to accommodate howitzers showed some flexibility of mind, given that the British had no more than a rumor to work with. White also noted that at the battle of Yalu, between the Japanese and Chinese Navies, gun crews at guns protected by casements had far lower casualties than those behind lighter gun shields. This underlined

\begin{itemize}
\item \textsuperscript{357} Ships Cover, Number 146, \textit{Canopus} Class, NMM.
\item \textsuperscript{358} Howitzers fire their shells with a high arc, which would cause the shell to strike the deck, not the more or less flat trajectory of naval guns at short ranges, which would strike the sides.
\item \textsuperscript{359} Report by William White on Design of First Class Battleship, \textit{Canopus} Class, May 30, 1896, TNA: PRO ADM 116/878.
\end{itemize}
for the Board the superiority of casement protection over gun shields for protecting secondary armament.  

In addition to upgrading to Krupp armor and modifications of armor placement, special attention was paid to restricting the use of wood to minimize fire risk. This appears to have been initiated by White, though the evidence is not conclusive. Restricting wood was an obvious step, considering the value naval opinion placed on robustness (the ability to function under harsh conditions at sea or under the assault of combat), and it is curious that this was not considered in earlier designs. One possibility that needs to be taken seriously is that senior naval officers just did not think of it. All of them spent substantial service time on wooden ships or ships with metal structures but wooden components. Ships were wood, at least in part. This fact inserted itself so firmly in their thinking that it receded to become a background assumption. It did not occur to them that wood was a potential hazard that could be eliminated, because it was a natural hazard of naval combat, like drowning. This would fit particularly well with the idea that it was White who initiated the drive to minimize wood. He would not have had the same assumptions about wood on ships—he would not have spent his professional career surrounded by it. A year later, in 1897, the Royal Navy began an extensive review to reduce flammable materials aboard ships.


361 Ships Cover, Number 146, Canopus Class, NMM.

362 Brown, Warrior to Dreadnought, p. 168.
The propulsion systems of the *Canopuses* received an upgrade as well. Ships at this time used steam-powered reciprocating engines. Steam was introduced into the cylinder, which moved a piston, which was connected to the shaft, which turned the propellers. The rotation of the shaft then pushed the piston back up into the cylinder, which forced the steam out, now at lower pressure as it expanded while pushing the piston. The action was very similar to that of an automobile engine, except that there was no combustion in the cylinder—the steam was heated in separate boilers. By the 1890s these boilers consisted of a cylindrical water tank mounted over a combustion chamber. The new style boilers on the *Canopus* class had Belleville type water-tube boilers. Water-tube boilers fed the water through tubes through the fire chamber, which offered a greater heat transfer surface and required less water circulating through the system from the boiler to the steam engine. These factors allowed for thus more steam production and thus more horsepower for the same weight. Water-tube boilers were also smaller, which allowed a few large cylindrical tank boilers to be replaced by several smaller water-tube boilers. The advantage here was more flexibility: at low power the unneeded boilers could be shut down, cutting coal consumption, but they could get up steam to functioning pressures more quickly in an emergency.363

Water-tube boilers had been an object of experimentation in the Royal Navy since 1865. The French had successfully employed them in warships from 1879, and the naval

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engineering firm Thornycroft had built the first one installed on a torpedo boat for the Royal Navy in 1885. The initial reaction of the Navy had been negative, as they suffered from a number of teething problems: leakage, tube blockage, and complete boiler failures due to bursting tubes. By the mid-1890s the reliability of water-tube boilers had improved markedly, and naval opinion was significantly improved. Improved naval opinion on water-tube boilers led to trials in smaller ships. Thornycroft water-tube boilers were installed into the torpedo gunboat *Speedy* and given extensive trials. Belleville water-tube boilers were also installed in the torpedo gunboat *Sharpshooter* for further, successful, trials. These trials were the key factors leading the Navy to adopt water-tube boilers in battleships, but there were other contributing considerations. Parkes cites the French installation of Belleville water-tube boilers in the battleship *Brennus* (laid 1889, completed 1893) and reports (which were correct) that

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368 The ship was severely overweight when completed (for reasons unrelated to the boilers) and the rebuilding was not completed until 1896. *Conway’s, 1860-1905*, p. 292.
the Russians were installing them in large ships.\textsuperscript{369} The British did pay close attention to developments in foreign navies and quickly adopted any advance that proved itself, and William White was very impressed with the boilers’ efficacy when he saw them on a trip to France.\textsuperscript{370}

Engineer Vice-Admiral Sir A. J. Durston, Engineer-in-Chief, also believed that water-tube boilers offered significant improvement over older boiler types, and wished to install them in the Royal Navy’s two newest cruisers, the \textit{Powerful} and \textit{Terrible}, before final results from the \textit{Sharpshooter} trials were in. White’s observations in France led him to support Durston, so it is not unreasonable to assert that successful installation and use by the French Navy played some role.\textsuperscript{371} However, it was the successful trials, first of the \textit{Speedy}, and then of the \textit{Sharpshooter}, that convinced the Board to use them in battleships.\textsuperscript{372}

It should be clear that the leadership of the Navy was not afraid of new technology—if they thought it worked. While water-tube boilers were the technology of the future, the Royal Navy had some problems with them. They tended to be slightly less fuel efficient (despite the trials showing them to be \textit{more} fuel efficient) and there were

\textsuperscript{369} Parkes, pp. 392-393, see \textit{Conway’s, 1860-1905}, pp. 180-185, 189-197 for specifications of Russian battleships and armored cruisers with water-tube boilers built before 1905.

\textsuperscript{370} Brown, \textit{Warrior to Dreadnought}, p. 137.

\textsuperscript{371} Brown, \textit{Warrior to Dreadnought}, pp. 136-137.

some significant problems with maintenance, which created reliability problems. Over the next few years, these issues created a significant debate within the Navy about whether water-tube boilers were appropriate technology or were in fact a step in the wrong direction. This will be discussed in some detail later. However, the Navy had every reason to think water-tube boilers would perform well given their use by the French and the endorsement of its two most important technical experts, Chief Engineer Durston and DNC White, and did not hesitate to adopt them.

The Formidable and London Classes: Limits to Personnel, Limits to Changes
The class following the Canopus, the Formidable class, showed very little change—so little that Parkes calls them “heavier looking editions of the Canopus.” They were actually new and improved Majestics. A series of conferences between White, Controller Fisher, and First Naval Lord Richards concluded that more firepower, better protection, and higher speed could be had for virtually the same size and weight thanks to improved technology. First Lord Goshen, who did not participate, was not so sure, but did not wish to argue. This acquiescence could be interpreted as the deference civilian First Lords showed to professional naval opinion, or as the willingness not to press personal opinion too hard in order to maintain harmony, or possibly both. Either way, the action is typical of the collegial, cooperative process of the time.


374 Ships Cover, Number 161A, Formidable Class, NMM.
The new ship was a better, but not bigger, *Majestic*. Its main armament was the new mark IX 12 inch gun with a higher muzzle velocity and better penetrating power, ready because the DNO had insisted that work begin on it a year before the new ships were laid.\textsuperscript{375} Krupp armor meant greater protection for the same weight, and Belleville water-tube boilers allowed for more horsepower and hence an extra 2 knots of speed for the same weight and space of boilers.

A new limitation, unrelated to technical or political factors, became influential enough to affect the design and capabilities of the ship—the size of the ship’s complement. White had wanted to add additional six-inch QF guns to the design, but the Board declined, citing space limitations and a reluctance to increase the ship’s crew size.\textsuperscript{376} Firepower was typically the first priority for the Royal Navy, at least for battleships, and these must have been issues of significant concern for the Board to oppose more guns. While it is impossible to disregard space as a factor, British warships were not known as roomy, and cramped conditions were regularly accepted.\textsuperscript{377} Jon Sumida and Nicholas Lambert have documented that the growing fleet began to have significant manpower problems at this time, both in terms of recruitment and cost, a

\textsuperscript{375} Minute from First Lord and response by DNO on new 12” gun design, Spring 1897, TNA: PRO ADM 256/33.

\textsuperscript{376} Parkes, p. 403.

\textsuperscript{377} While living conditions on board British vessels were better than on the ships of other European fleets because British ships were designed to be at sea for extended periods, living space was still fairly limited, especially on smaller vessels. TNA:PRO ADM 116/365
condition that was to plague the Royal Navy right up to World War I.\textsuperscript{378} It is quite likely that the Board had become concerned about having enough personnel to meet full manning requirements. Design documents begin to show a significant concern with the size of the ships complement.\textsuperscript{379}

Weight was also an issue, as a crewman’s kit and the required additional stores added a surprising amount to a ship's weight. However, the \textit{Formidables} were not squeezed for weight the way many designs were. The weight of equipment, supplies, and crew to perform the ship’s functions as desired by the designer was well within the amount of weight “available” with the size allocated for the ship. Most of the time, desired capabilities require more weight than is available, and compromises and trade-offs need to be made to keep the weight down. In addition, weight is almost always added during construction as unanticipated problems are encountered or last minute additions or changes to ships systems are made. The \textit{Formidables} did not have either problem and no great effort was needed (beyond routine caution) to keep their weight from increasing unacceptably.\textsuperscript{380} Limits on the ability of the Royal Navy to recruit and, more importantly, the budgetary limitations on the number of personnel that could be


\textsuperscript{379} Ships Cover, Number 161A, \textit{Formidable} Class, NMM. See ships’ covers for subsequent and previous classes for the growing importance of controlling ships’ complement.

\textsuperscript{380} Parkes, p. 404.
employed by the Navy, had begun to impose limits not just on the number of ships, but on their characteristics as well.

The next class of ships, the *London* class, was only slightly modified from the *Formidable* class. This was not the original plan, but a lack of staff in the Controller’s office, including the Constructor’s office, which worked on ship designs, prevented the completion of an intended new design. Intelligence reports indicated that Russia was building a new class of battleship, the *Peresvet* class, which would be faster than any British battleships. The Admiralty originally planed to build a battleship to emphasize speed, much like the *Canopus* emphasized a shallow draft, in order to counter these Russian ships. Also like the *Canopus* class, this would have required a significantly lighter ship and, thus significant revisions in design from the *Formidable*, upon which the design would be based. In order to use the funds for construction efficiently, plans had to be distributed to the dockyards by fall of 1898 so that construction could begin over the winter of 1898/1899. However, the understaffing at the Controller’s office interfered. There was not enough staff to finish the plans for a substantially different new ship and complete work on the other, higher priority, business of the office, including budget work and finishing ships already begun. Technology takes intelligence and commitment of resources to produce, but it also requires someone to undertake the skilled, sometimes highly skilled, routine work of translating ideas into actual functioning systems. While the disruption of the production of an entire ship class was extreme, short staffing at the

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381 Parkes, p. 408.
Admiralty was in part responsible for the slow pace of work the Navy’s bureaucracy was infamous for. 382

White, as he so often did, provided the solution, suggesting that three more Formidable class vessels could be built instead of a new design. This would allow plenty of time for the details of the new design to be worked out and still use the allocated funds in a timely and efficient manner. The Board agreed. The Controller’s office informed the dockyards that the new ships would be the same as the Formidables, except for some modifications to the armor distribution. 383 Indeed, the ships are similar enough that their ship’s covers, the compilation of documents relating to the design and construction of a ship class kept by the Navy, have the same number, 161, with only the suffix “A” to differentiate the Formidables (161A) from the new London class (161). 384

The only significant difference between the Formidables and the Londons was armor distribution. White had planned a new distribution for the delayed fast battleships, and this was adopted as an improvement on the protection for the Londons as well. 385 The forward longitudinal bulkhead, previously a standard feature, was eliminated in the Londons. It was replaced by extending the main belt, though gradually thinning, to the


383 Ships Cover, Number 161, London class, NMM

384 Ships Cover Formidable, no. 161A and London, no. 161 NMM. Considering that the Formidables were first, it does not make sense that they received the “A” tag, but the Admiralty records office was a government agency and “sense” was not necessarily part of the bureaucratic process.

385 Ships Cover, Number 161, London class, NMM
bow, and by extending the armored main deck, thickened to one and one half to 2 inches to the bow. It was thought that the thicker main deck would give better protection from high angle fire, as well.\textsuperscript{386} Beyond these changes it is difficult to distinguish between them and their predecessor class, the \textit{Formidables}.

\textit{The Duncan Class: Speed through Hull Design and Weight Control}

However, the next, faster class of battleships did not have long to wait. An unexpectedly larger Russian building program, an unsettled situation in the Far East, the growth of “third party” navies (German, Japanese and America), and British diplomatic isolation were significant worries to the Admiralty and the British government. A labor dispute which disrupted maritime engineering firms, and caused delays to British naval shipbuilding by holding up the delivery of machinery and other contracted parts of ships, also created unease at the level of naval preparedness. In this situation, the Government introduced a supplementary building program in July of 1898 that authorized the building of four new battleships as well as additional cruisers and destroyers.\textsuperscript{387}

After distributing the plans for the \textit{London} class to the dockyards, the Constructor’s office began design work for the desired faster battleships that were to become the \textit{Duncan} class. Designing a ship with the desired speed without sacrificing too much in the way of other functions (e.g. firepower, protection) was a challenging task. Speed is a function of the mass of the ship, the horsepower generated by the

\textsuperscript{386} Parkes, p. 409.

engines, the efficiency with which the propeller converts that horsepower to thrust, and
the resistance of the ship through the water. All of these came under scrutiny by the
Constructor’s office.

The easiest issue to address was engine horsepower. Ships at this time used steam
powered reciprocating engines. Early steam engines used steam at or near atmospheric
pressure, which limited the amount of work they could do. As steam engines became
more sophisticated, the steam pressure was increased. Once the pressure was high
enough, the waste steam from the cylinder retained significant enough pressure to be
introduced into a second cylinder, to drive a second piston connected to the propeller
shaft, which meant more power available to drive the ship. By the mid-1880s triple
expansion steam engines were being built, which created steam at up to 200 pounds per
square inch, which ran through three separate cylinders, at high, medium and low
pressures.

The engines for the Duncan were a new four-cylinder triple expansion type. The
steam was still only expanded three times, but instead of only one low pressure cylinder it
used two, each receiving a share of the exhaust steam from the medium pressure cylinder.
These engines were capable of generating 18,000 horsepower, 3000 more horsepower
than the three-cylinder models of the Canopus, Formidable and London classes. The
four-cylinder triple expansion engine was the pinnacle of reciprocating engine design—
there would be nothing better until the turbine engine. Marine engineering was a British
specialty, and the Royal Navy took advantage of this, as it had for most of the 19th
century, to remain at the forefront of warship engines. Four additional Belleville water
tube boilers were added to the *Duncans* over the standard 20, to supply the steam to run the new engines.

Converting that horsepower to thrust was a more difficult issue. Estimating the efficiency of the propeller and the ship’s resistance through the water caused considerable difficulties for ship designers. However, the Royal Navy had overcome this difficulty by using the work of William and Edmond Froude. William Froude was an engineer who began working on hydrodynamics in the 1850s. By the late 1860s he had demonstrated that there was no single optimum hull shape, but he had also proven mathematically that the resistance of similar forms had a relationship to the speed and hull length, and that it was thus possible to use models to determine resistance.\(^{388}\) Froude convinced Edward Reed, the DNC at the time, and Reed, after some indecision, convinced the Board to fund an experimental works run by Froude.\(^{389}\)

The Admiralty Experimental Works was up and running in 1872, the same year Admiralty trials confirmed that actual resistance conformed closely to Froude’s estimates. By this time Froude had also been able to develop separate models for determining friction resistance and for separating that information out of the results for overall resistance. In 1873 Froude began work on propeller performance as well. William died in 1879 and his son Edmond replaced him, and continued to run the

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\(^{388}\) The formula: resistance per ton of displacement = speed divided by the square root of length.

\(^{389}\) See TNA: PRO ADM 116/137 for initial Admiralty discussions of Froude’s work and funding for his facility.
establishment, which was moved to a larger facility in 1887, for forty years. This facility, at Haslar in Portsmouth, was very different from the other most important experimental stations run by the Navy, which were attached to and grew out of naval schools. The HMS Excellent (the gunnery school) and HMS Vernon (the torpedo and electrical school) conducted experiments in their respective fields. They were schools first and experimental stations second, and if staff and time ran short, experimental activity might be severely limited or even eliminated.

Haslar, however, was a dedicated facility, the only one in the Navy until a station for experimenting on oil opened in 1902.

Haslar existed for two reasons. First, Edward Reed, its sponsor, needed it. Since iron ships were new, shipbuilders lacked the experience that guided them in the construction of wooden ships, and there was relatively little theoretical knowledge of the physics involved, so there was often no reliable way to predict how ships would act under various conditions. The debates about what constituted a good design were intense, and without data were often a matter of opinion. Reed needed data and Froude offered a means to acquire hard, quantitative data with which decisions could be made, even if that

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390 Brown, Warrior to Dreadnought, pp. 70-71.


data did not bear directly on the issues of most intense debate. Reed deserves credit for recognizing the value of Froude’s work and harnessing it for the Navy. Froude’s facilities were also cheap. He needed little staff, few materials, limited equipment, little land and only a small structure. Froude asked for only £2,000 to set up and run the establishment for its first two years. Thereafter, the Navy continued to fund the facility, with Froude (and later his son) and its small staff, as a permanent research establishment. The establishment at Haslar did not absorb enough resources to create serious objections either within the Admiralty, which might have wished to use the funds elsewhere in the Naval budget, or in Parliament, which would not have wanted to spend the money at all. Froude and the Haslar works offered tremendously valuable information at very little cost.

This experimental works, unique among the military establishments of the world, gave the Royal Navy a significant advantage in ship design. It provided enormously valuable data for optimizing hull form based on the other parameters set for the ship. This research allowed for very direct translations of horsepower to speed, and thus


394 Brown, Warrior to Dreadnought, p. 71.

395 Brown, Warrior to Dreadnought, p. 71. Dr. Tideman, a Dutch physicist, developed a similar approach but was hindered by lack of funds. See J. M. Dirzager, “Contribution of Dr. Tideman to the Development of Modern Shipbuilding,” from the conference Five Hundred Years of Nautical Science at the National Maritime Museum, Greenwich, 1981, cited in Brown, p. 71. Private shipbuilders began building their own tanks in Britain by the 1890s but most were smaller and less accurate. The first full sized tank opened by major warship builder was opened by John Brown in 1907. See Lyon, p. 45.
allowed for a relatively rapid determination of the size of the machinery needed to attain any desired speed. Froude was also able to develop accurate scaling to allow for experimentation on scale propellers, which allowed the determination of the optimum size, shape, and speed of the propeller given other parameters (e.g. projected speeds, hull form and ship’s weight). With the ability to consult Haslar for resistance data, the process of determining the design speed of a ship was a matter of calculation. Nathanial Barnaby, Reed’s successor and White’s predecessor as DNC, wrote that never had £2,000 been so well spent, and greatly credited Frounde’s work for improving ship design. With the ability to convert horsepower to speed for any given hull form and weight, the main design decision became how much space and weight were to be devoted to the generation of horsepower for propulsion.

The data derived from this work became so respected that it was allowed to trump what was normally the ultimate standard for the Royal Navy: practical experience. In 1903 the Controller, William May, wanted to try modifications to hull form to reduce pitching, and was able to cite interest from within the active fleet in support of his ideas. Phillip Watts, the DNC who replaced White, pointed out that much data existed from the Haslar works indicating it would have no effect, and Admiral Lord Walter Kerr, the First Naval Lord, did not wish to devote the resources to it. However, May was persistent in wanting a trial under seagoing conditions, and eventually convinced a reluctant Kerr and First Lord Selbourne to approve his proposed modifications for the Duke of Edinburgh.

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class cruisers. However, Watts reported further experiments by Froude were even more conclusively against May’s modifications, and Kerr, despite May’s insistence that only a real trial could be conclusive, canceled the project, citing the definitive nature of the Haslar data. Far from ignoring evidence it did not like, then, the senior leadership of the Navy embraced quantitative evidence where it was conclusive.\(^{397}\)

While Froude’s work had been important for ship design for twenty-five years, particularly on smaller ships, the team at Haslar had never been called upon as heavily in the design of a battleship as it was for the *Duncan* class.\(^{398}\) White and the Constructor’s office drew heavily on them to improve the hull form. Drawings were sent to Haslar where they were used to construct models, which were then evaluated. Haslar reported results and made recommendations on changes to hull form to increase the ship’s speed. The Constructor’s office made modifications, sent new drawings to Haslar, and more tests followed. Eventually, after a significant amount of interaction between the Constructor’s office and Haslar, the hull form was finalized: slightly longer, wider at the beam, and of shallower draught than the *London* class.\(^{399}\)

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\(^{397}\) Correspondence between Controller W. H. May, DNC Phillip Watts, First Naval Lord Kerr and First Lord Selbourne, February to July, 1904, TNA: PRO ADM 116/964.


\(^{399}\) Ships Cover, Number 162, *Duncan* class NMM.
This process is very similar to what engineer Walter Vincenti calls the variation-selection model, essentially a model of how new knowledge is gained. Specifically, it often applies to seeking knowledge of an engineering application that solves a problem. Attempts to solve a problem are made and somehow tested, either in a full scale trial or a vicarious trial using some form of model. An acceptable or best answer emerges from the process. In this case, the search was for a hull form that moved through the water in the most efficient matter possible, that is, one that could achieve a suitable velocity driven by the given horsepower generated by the engines, subject to certain restraints (e.g. draft and broad limits on length and beam). Various hull forms were tested, the results evaluated, and new variations were tried. Ultimately, a hull form was found that was sufficiently better than other options to be acceptable.

This is not a method of investigation engaged in by “reactionary” individuals stridently against change. Such individuals would most likely just have used a current hull form, and saved the time and effort of pursuing something they did not like and did not want anyway. While the process was driven by Froude and White, two very capable engineers willing and able to press ahead in search of new knowledge and superior techniques and equipment, naval officers were also a part of the process. At the very minimum, the Board, composed of senior (read older) naval officers, tolerated the approach in an attempt to get what they wanted—a faster ship. However, it is likely that

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Walter Vincenti, *What Engineers Know and How They Know It, Analytical Studies from Aeronautical History* (Baltimore: Johns Hopkins University Press, 1990), especially chapter 8, “A Variation-Selection Model for the Growth of Knowledge,” pp. 241-257. Many pieces of ship and ship systems design could be described using this model; it just happens to match up exceptionally well here.
the attitudes of naval officers went beyond this. Froude’s establishment at Haslar had been operating to the Navy’s great benefit for over twenty years by this time. Modeling and testing for optimum hull form had become routine for the Royal Navy. Naval officers valued the knowledge gained by using the process because it could be translated directly into improved capabilities for their ships, so they supported the pursuit and application of such knowledge.

The final requirement, keeping the Duncans’ weight down, proved very difficult, and the ship’s design weight rapidly grew into the “standard” range of the Majestic, Formidable, and London classes. The engineering plant was significantly larger and heavier than on older classes, and the armament of the previous three classes (the Canopus, the Formidable, and the London) was mostly retained; only six twelve-pound QF guns were omitted. However, an even larger power plant would have been needed to achieve the desired 19 knot speed at that weight, and this would have made the ship even larger. This was not acceptable to the Admiralty. Brown suggests that cost was the major factor, and Parkes suggests that small ship advocates, while they could not prevent ships from growing into the 15,000 ton range, were able to apply enough pressure to keep ships from getting any larger.

About 1,000 tons of weight needed to be cut to lighten the ship enough to make 19 knots. Several hundred tons were eliminated by revisions to the hull design and other modifications designed to lighten the ship, and the dockyards’ paying special attention to

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401 Ships Cover, Number 162, Duncan class NMM.

402 Brown, Warrior to Dreadnought, p. 146; Parkes, p. 416.
keeping weight down saved several hundred more.\textsuperscript{403} However, the bulk of the weight savings had to come from a reduction in armor. The main belt was reduced to seven inches of Krupp steel, and various other parts, including the aft longitudinal bulkhead, were reduced as well. The horizontal armor at the waterline (which also provided backup for the main waterline belt, thanks to the angling earlier introduced by White) was also reduced to one inch, compared to three to four inches for the \textit{Majestics}, two to three for the \textit{Formidables}, and one on the flat and two on the side slope for the \textit{Londons}.\textsuperscript{404}

These were substantial reductions, and left the ship significantly less protected than the \textit{Formidables} and other earlier classes. It was hardly enough to withstand fire from medium caliber guns at battle range, and technically able to withstand fire up to only 6.3 inch shells. This cannot be construed as anything but a deliberate decision. Speed was deemed necessary, armament was not to be compromised, and size could not be increased. Something had to give, and the Board, likely with the approval of most of the “college” and other officers who thought about it, sacrificed protection.\textsuperscript{405} Despite considerable approval, or at least acceptance, of the reasoning within the Navy, there was criticism of the arrangement of the armor. The thinness of the waterline deck and the presence of any armor at all on the main deck came in for particularly sharp criticism.\textsuperscript{406}

\textsuperscript{403} Parkes, p. 416; Ships Cover Number 162, \textit{Duncan} class NMM.

\textsuperscript{404} Parkes, p. 409; \textit{Conway’s 1860-1905}, p.37.

\textsuperscript{405} Letter from Custance to Bridge on “fortress ships,” BRI 15m pt. 2, NMM.

\textsuperscript{406} Parkes, pp. 417-418.
The waterline deck provided important support for the main belt on its side slopes, and given the relative thinness of the main belt the thin slope was seen as inadequate backing.

More importantly, the main deck armor was not viewed as an effective use of armor weight. The French experiment with howitzers was not successful and so no defense against them was needed.\(^{407}\) The weight of the main deck armor would have provided five more inches for the main belt, or doubled the thickness of the waterline deck.\(^{408}\) White, however, presented a spirited defense of the main deck armor in *Brassey’s The Naval Annual* in 1904.\(^{409}\) He argued that a roll of only 10 degrees exposed three and one half feet of horizontal deck to direct fire. This needed some protection to prevent heavy shells from blowing out large chunks of deck and supports for the main belt armor. Critics responded that such splinters were unimportant and the areas most likely to be affected were generally empty in combat and not vital.\(^{410}\) Critics within and outside the Navy may have been vocal, but White got his way, showing his authority with the Board.

As the emergency program construction of four *Duncans* was well underway, discussions within the Admiralty turned to the two ships that were to be part of the 1899-1900 estimates. A memo circulated by the Controller seeking opinions returned a consensus for more *Duncans*. First Lord Goshen, however, was not yet ready to agree, 

\(^{407}\) Parkes, p. 419.

\(^{408}\) Parkes, p. 418.

\(^{409}\) Cited in Parkes, p. 418.

\(^{410}\) Parkes, p. 418.
and scheduled a conference for August. On August 2 the Board and DNC White met, and formally approved the Duncan class for the upcoming builds.\textsuperscript{411}

There are two particularly interesting aspects of this course of events. First, the naval members of the Board were quite ready to move forward on the basis of a circulated memo, without any face to face meeting. However, the politician, First Lord Goshen, was not. Also significant is the parallel between Goshen’s interactions with the Board in this case and those with the decision to build the Formidables. As noted above, Controller Fisher and First Naval Lord Richards, the two central service members of the Board concerning new construction along with DNC White, decided that improvements in technology would allow significant improvements over the Majestics with no increase in size. In this case, the consensus of the uniformed members of the Board and White was that the best ships to build were more of the Duncan class. In both cases, Goshen was skeptical of the conclusion reached, but willing to accept it after a full conference. It’s unclear how much of this was due to Goshen’s reluctance to overrule the advice of the service personnel on the Board, or due to his desire to remain collegial and endorse a proposal as representing consensus. Likely, both were factors and this case serves as an example of how business was conducted at the highest levels of the Navy.

\textit{High Technology Communications: the Early Days of Wireless}

While these ships were designed, built and put into action, an important development was underway in how they would be used. Electricity was not only changing intra-ship

\textsuperscript{411} Ships Cover, Number 162, Duncan class, NMM.
communication, as described previously; it also began to make itself felt in inter-ship communication, long dominated by flag signaling systems. Wireless telegraphy (W/T) or radio promised the ability to communicate between points without physical connections, by using electricity to generate electromagnetic radiation in patterns, which could be received and deciphered—Morse Code, already in use for the telegraph, provided a readily available system. Command and control issues had been under discussion for decades and wireless looked like a tool that might solve many problems.\textsuperscript{412} The Royal Navy grasped the significance and usefulness of the wireless quickly, and it aggressively pursued its development in a way that was typical of its approach to new technology.\textsuperscript{413}

Ship to ship communication in the late 19\textsuperscript{th} century was primarily by flag signals. Partly as the result of overly rigid centralization of authority and a culture encouraging unthinking obedience, the flag system became increasingly complex as commanders tried to develop a means to impose their will on a fleet in action. There was some debate during the 1880s and 1890s about how effectively even simple commands, never mind complex ideas, could be communicated by flag. Reforms, though, were minimal, and the system stayed. However, this did not mean that the limitations of flag signaling were not recognized but just that it was the only available means of command and control.\textsuperscript{414}

\textsuperscript{412} See Andrew Gordon, \textit{The Rules of the Game, Jutland and British Naval Command} (Annapolis: Naval Institute Press, 1996) for a discussing of the history of command and control discussions within the Navy.

\textsuperscript{413} Extracts from a Report on Experiments carried out by M. Marconi, 1898, TNA: PRO ADM 189/18.

By the late 1800s quite a number of individuals were experimenting with wireless transmission, and by the mid-1890s functioning “radio” could be claimed to have been invented by a number of them, including, most famously, Gugliemo Marconi. The Royal Navy was also fortunate to have a pioneer in the development of wireless as one of its own: Henry B. Jackson, who began his experiments as a Commander in 1890 and made his first successful W/T transmission while in command of the Defiance in 1895.

Initially, the Navy closely observed the individual efforts of Marconi, Mr. W.H. Preece, and Captain Jackson (promoted in 1896). Marconi and Jackson initially pursued independent efforts developing effective practical uses, though they began to cooperate in 1896, and Mr. Preece’s experiments “were mainly designed with a view of determining the laws which govern this method of transmission.” HMS Vernon, the torpedo and electrical school and experimental station, was given the responsibility to oversee wireless development. At first, its role was primarily as a conduit for passing reports of these experiments, including precise details of the equipment and experimental procedures, on to the wider Navy. However, Marconi’s demonstration in 1898 was successful enough that the Navy decided to take a more active role, and three sets of


416 Report by Command H. Jackson on his experiments on H.M.S. Defiance, TNA: PRO ADM 189/16.

417 Extract from the Report on Experiments with Wireless Telegraphy carried out at Dover by Mr. W. H. Preece, TNA: PRO ADM 189/16.
wireless apparatuses were obtained and fitted to the *Alexandra*, *Europa*, and *Juno* for the 1899 maneuvers.\textsuperscript{418}

The trials at the maneuvers were very successful. Great care and expertise were required to set up the equipment, but there were no problems with it requiring constant correction. The report also noted “any average electrician and good telegraphist could manipulate the instruments when once adjusted,” though an expert was needed for the initial adjustment.\textsuperscript{419} Communication between vessels and with a shore installation was successful at up to 100 miles, though fifty miles was more conservatively reported as an effective range.\textsuperscript{420}

Two developments marked 1900: Captain Jackson’s apparatus achieved rough parity of effectiveness with the Marconi system, and investigation of W/T systems moved into high gear, motivated in part by the successful trials during the 1899 maneuvers. Captain Jackson conducted a series of experiments with both his own system and the Marconi system, which furthered practical understanding of the process. Jackson was remarkably unbiased in his assessments of both systems, though he did favor his own,

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\textsuperscript{418} Gordon, p. 319.

\textsuperscript{419} Extracts from a Report by Lieutenant Salwey on the Instruments fitted in *H. M. S. Europa; A similar Installation Being Also set up in H. M. Ships Juno and Alexandra,*” (Peace Maneuvers, 1899), TNA:PRO ADM 189/19.

\textsuperscript{420} Extracts from a Report by Lieutenant Salwey on the Instruments fitted in *H. M. S. Europa; A similar Installation Being Also set up in H. M. Ships Juno and Alexandra,*” (Peace Maneuvers, 1899), TNA:PRO ADM 189/19.
slightly.\textsuperscript{421} Extensive trials were also held on both systems, and they were used for the 1900 fleet maneuvers. Weather and other atmospheric phenomena complicated use, and there was a growing comprehension of the factors that affected performance of W/T. Reports from the captains of ships involved with W/T were positive, an important factor in the consideration of new technology. The Navy worked with growing understanding of the principles and use of W/T, and found itself in possession of two high quality systems worthy of further development.\textsuperscript{422}

The Navy was also rapidly learning not just technical lessons, but also how to use W/T. It had great potential, but there were also significant limitations on the system. One was lack of security in transmission. The \textit{Vernon’s} annual report stated: “It should be borne in mind that there are many wireless installations out of the British Navy, and, for this reason, no confidential signal is to be spelt [sic] by wireless, but should always be sent in code.”\textsuperscript{423} The Royal Navy recognized the importance of signals discipline and the danger of W/T signals giving away important information. The other major limit that was discovered was that the increasing number of signals caused mutual interference or overwhelmed the receiver’s ability to sort the information coming in, and thereby threatened to make W/T unusable.\textsuperscript{424} This would be partially solved with the

\begin{footnotesize}
\begin{enumerate}
\item Report by Captain Jackson on Experiments with Service and Marconi Instruments; Remarks by Captain Jackson and \textit{Vernon} attached, TNA: PRO ADM 189/20.
\item Various reports from the 1900 Naval Maneuvers, TNA: PRO ADM 189/20.
\item Summary Report from \textit{Vernon} on Experiments Carried out in the 1900 Naval Maneuvers, TNA: PRO ADM 189/20.
\item Various reports from the 1900 Naval Maneuvers, TNA: PRO ADM 189/20.
\end{enumerate}
\end{footnotesize}
introduction of multiple frequencies, but it remained a problem and further contributed to
the Navy’s hesitation to depend too much on W/T for communications.\textsuperscript{425} It also
suggested to a few creative officers the potential for jamming transmissions, which was
successfully tested during the 1900 maneuvers.\textsuperscript{426} The great superiority of Great Britain
in W/T security and signals intelligence over the two world wars began to germinate
here.

The technical and operational facets of W/T continued, though wireless did not
fully replace flag signaling systems until much later. The Navy’s work with W/T is
reflective of its approach to technology in general. First, it established an early interest in
a technology that would address important naval needs—communication, command, and
control. However, it devoted minimal resources to experimentation itself. Instead, it was
an interested observer at trials made by private individuals or, in Captain Jackson’s case,
naval officers acting on their own initiative. Once a system seemed to be in working
order, it invested resources in trials under conditions of stress—ships on duty at sea.
Once that was successful, it adopted the technology and continued to participate in the
practical aspects of its development. The Navy also quickly learned the strengths and
weaknesses of the device, both technically and operationally, from its trials under
operational conditions. Finally, the Navy did not discard its older technology, in this case
flag signaling, until the new technology was fully capable of replacing it. Instead, it used

\textsuperscript{425} Gordon, pp. 85, 354-355, 488-489, 506.

\textsuperscript{426} Report from \textit{Vernon} on Wireless trials during 1900 Maneuvers, TNA: PRO ADM
189/21.
new technology where the older would not work, in this case for communications beyond sighting distance, and gradually replaced, while not completely discarding, the older technology as the capabilities of the new technology expanded.

**Conclusion**

During the second half of the 1890s, the British, the politically interested public, the Government and Parliament, and the leadership of the Royal Navy all perceived the need for a growing fleet. Battleships, the core of the fleet’s fighting power, were built in response to that need. They continued to be built using the successful pattern of the *Royal Sovereign* and *Majestic* classes. That pattern established not only the basic design parameters of the ship, but also the process that made decisions and the method of bringing new technology into the Royal Navy’s battleships.

While the ships were all similar, they were not all the same. The basic pattern was adapted so that each class of ship could fill slightly more specialized functions that might be needed from battleships. The ships also reflected gradual incorporation of new technology to improve their performance; guns, armor, and the engineering plant all benefited from these improvements. The process of electrification moved forward steadily as various problems were solved, and standards and equipment developed. This was not a period of where the Royal Navy froze in place on technology, but a time of constant adjustment and improvement.

Beyond these incremental developments, the Royal Navy was one of the earliest organizations actively observing and then testing a radical technology: wireless
telegraphy or radio. W/T held the promise of solving significant problems for the Royal Navy—ship-to-ship communication and command and control—especially under combat conditions. However, the Navy moved forward at a deliberate pace, cautiously observing and then experimenting. It also began the process of figuring out how W/T needed to be used to maximum effect—that is, it began to investigate the way W/T would change how the Navy had to think about communication. The cautious approach did not signal that the Navy was resistant to W/T as much as it was a recognition that W/T was not nearly ready to fulfill its promise.

The system for decision making continued to function smoothly. White remained its leader and the leader in integrating new technology into new ships. While White’s individual efforts helped the Navy move quickly on new technology, his word alone was not enough to drive the process. Instead, White, the Board, and the rest of the Navy’s decision-making college were all dependent on empirical data. This period highlights the Navy’s aggressive use of testing and trials, especially comparative trials, to gather the information necessary to make decisions on new equipment and technology. The experimental works at Haslar, which was itself cutting edge technology, exemplifies the Navy’s desire for hard data with which to make decisions. Again, this is not the approach of technophobes avoiding the new at all costs, but the efforts of cautious professionals demanding new technology prove itself “better” before adopting it.
Chapter 5:  
Adapting the Pattern: Changing the Ships, but not the Methods

Introduction

The standard pattern battleship, and standard pattern development process, worked out with the Royal Sovereign and Majestic classes, had served the Navy well through the 1890s. However, both the pattern for the ships and the pattern for the process began to run into trouble after 1900. The heart of the problem was that the standard pattern battleship, while fundamentally sound as a weapons system, no longer offered adequate fighting power—their secondary armament of six inch guns was no longer heavy enough. Improvements in the ships of other navies meant that improvements were needed if the Royal Navy wanted to retain superior ships on a unit to unit basis. The Board wanted more of everything—more firepower, more protection and more speed—except the one item needed to make those desires reality: increased size and expense. It was not possible to meet the Navy’s goals and ultimately the Navy opted for larger, more capable ships. However, while the larger ships allowed for increased capabilities, the new size was still not large enough to easily reconcile the different demands on the new ships. Given this, less consensus and more conflict were all but inevitable. The smooth, collegial process degenerated into one fraught with conflict and delay. Even so, the system did not break down entirely. Compromises were made and ships were built. The basic pattern ship
was modified and the basic pattern process showed itself to be robust enough to function successfully under difficult conditions.

As discussed before, any warship is a “basket” of capabilities and the size of the basket is the weight it can carry and its volume and shape. The laws of physics are the only hard and fast limit; all other issues involve trade-offs. Size itself is an asset to a ship that can be balanced against cost: larger ships are more expensive. Once size is determined, fitting capabilities within the basket involves trade-offs between different goals. For example, more armor means less weight is available for guns, engineering plant, etc. To give a ship more capabilities in one area, for example bigger or more guns, involves trading off capabilities in another, or accepting the trade off of a larger, more expensive ship. The leadership of the Navy wanted neither to make sacrifices in capabilities nor make the ships larger. The unbreakable limits imposed by physics, however, forced a decision. The leadership of the Navy absolutely determined that more capable ships were needed and chose to make ships larger.

They did not, however, give themselves enough “room” to include everything that was thought to be absolutely necessary by some individual or substantial faction. This was the root of the deterioration of the ability of the Board and the rest of the College to come to agreement. It was far easier to create a consensus or make accommodating compromises when the limits imposed by size were loose enough to allow almost everyone’s “absolute must have” to be included. Nor was it acceptable to build multiple

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427 Recall that the weight of the ship is measured as the weight of the water it displaces floating. One can add more weight but if the weight of the structure and load of the ship is heavier than the water it displaces, it sinks. Shape and volume have importance because of the implications of where the weight is distributed for stability.
different designs at the same time in an attempt to accommodate different opinions, which had been done when the Hood was built as an alternative to the Royal Sovereign class in 1889.

Related to this problem was a decline in willingness to compromise. If a particular officer deemed a certain level of a capability, for example a certain speed, absolute necessity, it could not be compromised away. Speed could not be allowed to drop below that minimum in order to have more of another capability. Since there was no general agreement on priorities (beyond no lessening on capabilities established by the standard pattern), there was a wider array of minimum capabilities to be accommodated.

Debate, which previously had proceeded at a deliberate pace as various options were discussed and then one chosen, slowed to a crawl as the various options were discussed over and over again. Even when choices had been made, the decision was often challenged later as the interconnected nature of ships systems allowed an issue to come once again into the discussion. Delays caused by the inability to make decisive decisions began to interfere with construction work as the yards waited for decisions. They also contributed to the decision to delay the introduction of the class of ships that was to become the Lord Nelson class and build additional ships of the King Edward VII class.

The tone of the debates was also enough to disturb officers who were not used to such a level of contentiousness. During the discussions surrounding the King Edward VII class the situation got so bad that First Naval Lord Kerr and another member of the Board proposed putting off any decision to avoid further acrimony. An even greater level
of acrimony surrounding debates on the configuration of ships’ boilers and the distaste of Kerr and others was palpable on the pages of their memos.

This time period also showed the role an individual could play in a process that was not dependent on abilities of any given individual. Unlike the positive role the individual ability and inclinations of William White, which had played during the previous decade, the five years between the turn of the century and the Dreadnought showed that individuals could also hinder the process. In 1901 White was lost to the process as age, ill health and a scandal over mistakes in the new Royal Yacht forced his retirement. At the same time, Admiral Arthur Knyvett-Wilson428 was Third Naval Lord and Controller and thus the member of the Board responsible for material, including ships. While he was generally respected as a sea-going officer, he was very difficult to work with and not inclined to compromise. In addition, Phillip Watts, White’s successor as DNC, proved unable to work well with the Board and attracted the particular ire of Admiral May, Wilson’s successor as Controller. Both of these men played important roles in making the process longer, more contentious and less effective than it had been.

While all of the tumult and debate around the design of ships and boilers was occurring, the Navy was still pushing forward with adapting and adopting new technology. The practice of trial and experiment did not subside nor did the search for quantitative information with which to make decisions. Whether it was trials on electrical equipment or the examination of the performance of boilers, the search for data

428 He was born Arthur Knyvett Wilson (no hyphen) and adopted the name Knyvett-Wilson at a later date. He is most often referred to by his original last name only (Wilson) or as A. K. Wilson.
shows officers, as a group, in a positive light. They were not men avoiding new technology but testing and evaluating new technology. They wanted a demonstration that the new technology, in the form available to them, was truly better and not just new.

Perhaps the most intensely investigated issue of the time was the efficacy of water tube boilers. They promised improvements over older types and in the long term delivered. However, they went through very significant “teething” problems after their adoption for the Canopus class, which created a feeling in parts of the Navy and the knowledgeable public that perhaps adopting them was a mistake. Expert opinion was collected and trials were conducted. The final report mostly vindicated water tube boilers, though the details of the decision sparked some of the most intense argument in the Navy for decades. A compromise, the use of both older and newer style boilers was recommended and adopted for several years. Importantly, Naval officers were more progressive than the civilian engineers who made up the bulk of the investigating committee, as the officers were opposed to the mixed complement of boilers and preferred the water tube type, regarding them as the “wave of the future.”

If technology is to be regarded as a system surrounding the construction and use of a particular object and not just the object itself, the Navy was also busy grappling with the new technology as it sought to determine the implications of the newest guns. Two studies, which again give focus to the Navy’s attempt to acquire information to make informed decisions, investigated damage potential of various size guns against armor under projected combat conditions. The information gathered had a profound impact on the armament and armor of British battleships going forward. They also showed how the
Navy was interested in finding out how to best use the new equipment they had and it was not content to just use the older methods. This is the work of men interested in technology, not the work of men interested in avoiding anything new.

In total, then, this was a difficult period for the Navy but not an unsuccessful one. The King Edward VIIIs and the Lord Nelsons both saw significant service in World War I. If they were not the equal of ships up to fifteen years and several generations of technological improvements newer, that can hardly be expected. They would have overshadowed the Royal Sovereigns of the Naval Defense Act just as thoroughly. Instead, these two classes of battleship show that the Royal Navy before Fisher and the Dreadnought had a well designed system in place to develop new battleships and deal with new technology.

Unpalatable Alternatives: Planning the King Edward VII class

Improvements in the technology of foreign battleships were threatening the superiority of the Royal Navy’s standard battleship by the turn of the century. The Admiralty was constantly monitoring the progress of technology in other navies. The six inch gun, the standard for secondary armament on battleships, was being replaced with eight inch guns in the late 1890s by the Italian and American navies. The New Jersey and Bennedetto Brin which had eight inch guns to supplement the 12 inch main battery are often cited as the ships which concerned the Royal Navy, but other ships in both the Italian and
American navies had previously had such heavy batteries for part of their secondary armament.  

Other navies were also upgrading the armor on their battleships. Krupp armor, which was more resistant than older types, was beginning to appear on the newest French and Russian ships. With thinner, but still just as effective main belts, these fleets used the weight saved by extending armor coverage to larger portions of their ships. Large areas of hull on enemy battleships were now immune to the effects of six-inch guns. Since the purpose of six inch guns was to riddle the unarmored parts of an enemy ship to make it combat ineffective without needing to penetrate the heavy armor to strike ships vitals, the value of six inch guns as anti-battleship weapons was seriously undermined.

The Admiralty had taken criticism for a number of years on the grounds its battleships were not heavily armed enough. William White, DNC and architect of the standard pattern battleships, submitted a report showing the comparative weakness of


431 Parkes, p. 422; Brown, Warrior to Dreadnought, p.146.
British designs.\(^{432}\) To increase the firepower of British battleships, the new battleship program for 1901-1902 was projected to include an intermediate battery of seven and one half inch guns, larger and more powerful than the six inch QF guns of the standard pattern. However, actually adding the guns was not so simple. Seven and one half inch guns are substantially longer and heavier than six inch QF guns, which meant that either the ships had to get bigger or other capabilities needed to be traded-off to increase the weight available to use for guns.

As previously described, within its specified weight and volume a ship has to make provision for armament, protection (the majority of which is armor), engineering plant to produce speed, fuel supply for endurance and various miscellaneous auxiliary items (e.g. small craft, crew supplies and kit, electrical systems). As a ship almost never has the capacity to accommodate all of the various systems desired, trade-offs between these different capabilities, particularly armament, protection and speed/endurance are required. The standard model British battleship was already “full” and reflected compromises and trade-offs previously made. There was no room for additional weight or space to fit larger items it into the hull. The easiest way to accommodate the extra weight and space needs of the new guns and their accessories (mounts, armor, ammunition, etc.) was to increase the size of the ship from the “standard” hull (about 430 feet long and 75 feet beam with a displacement of 13,000-15,000 tons, up to 16,000 tons at deep draught). White pressed for a larger ship early in the process.\(^{433}\)

\(^{432}\) Ships Cover, *King Edward VII* Class, NMM.

\(^{433}\) Ships Cover, *King Edward VII* Class, NMM.
There was considerable resistance, however, to larger ships. Larger ships cost more and the naval budget was already high and growing fast. The money had to come from someplace and Governments, even Conservative Governments willing to spend significant sums on the military, had to balance said spending with general political resistance to taxation and deficit spending. The leadership of the Navy, while willing to ask for more money, was cognizant of budget limitations and did not want to ask for more than it was likely to get. It was also unwilling to make the trade-offs within the naval budget to direct an increased amount of spending toward battleship construction.\footnote{Sumida, \textit{In Defense}, pp. 3-28; Nicholas Lambert, \textit{Sir John Fisher’s Naval Revolution}, (Columbia, University of South Carolina Press, 1999), pp. 15-37.}

In addition, there was reluctance both within the Navy and the narrow sector of the general public that was knowledgeable about naval engineering and naval affairs to make ships larger. Much of this apprehension was focused on the concern that very large, expensive ships rendered the Navy vulnerable by “putting all its eggs in one basket.” This debate, it will be recalled, was a central issue when the \textit{Royal Sovereigns} and \textit{Majestics} were being designed and built at the start of the 1890s. Large ship advocates won decisively at that time. Some continued to advocate smaller ships “to spread the risk,” and the issue remained quietly beneath the surface for the balance of the decade. Ships larger than the standard design were certain to rekindle the debate and the Naval leadership did not wish to deal with the probable controversy.

There were also those within the Navy who thought ships were already too large and complicated for the Captain to thoroughly understand and effectively control during
battle. This argument is not as irrational as it may seem to some. These ships, though small by modern standards, were very large and internal communication was a constant challenge. Voice tubes provided some improvement over runners and the telephone was generally an improvement over that. Clarity of communication could be a problem as messages could be garbled and all methods of communication were vulnerable to battle damage. Battleships also contained an enormous number of very complex subsystems that a captain had to have at least some familiarity with to understand the capabilities of his ship. It was somewhere between difficult and impossible for Captains to have the level of technological knowledge that some thought necessary. Both of these problems could be, and were, overcome—continuing improvements in telephone technology made intra-ship communication more reliable. It was not really necessary to know every working detail of every system; Captains only needed to know the general capabilities and trust the ship’s technical experts. The argument that larger ships exceeded the limitations of communication and the Captain’s ability to command them was ultimately wrong, but it was not unreasonable.

Finally, larger ships would also require changes in naval yard infrastructure. Docking facilities were only capable of handling ships slightly larger than the standard design – and substantive increase in beam, the ships width, would render a battleship too large to fit. Building larger naval yard facilities would have been expensive and taken time.\footnote{Ship’s Cover, \textit{King Edward VII} Class, NMM.} All of the issues surrounding increasing the budget for building ships applied here as well.
The Board, recoiled from the alternative of reducing other capabilities, such as armor or speed. Admiral A.K. Wilson, the Controller, was insistent that the ships achieve a speed of at least 18.5 knots and was equally insistent that armor protection not be reduced. While there was some irritation at his intransigence, his basic point, that less speed or protection would be unacceptable, was acknowledged. The Board would not countenance any reduction in protection or speed.\(^\text{436}\)

Since both a larger ship and reduction in other capabilities were rejected, the Board began to consider forgoing a larger gun. This, however, was unattractive given the perception that newer battleships needed heavier guns. The relative merits of the two guns, 6 inch QF and 7.5 inch, as well as all of the surrounding issues of placement, protection and weight were debated extensively. The Board, despite extensive and contentious debate, could not decide if the 7.5 inch gun was really needed. Finally, Admiral Custace, the highly respected Director of Naval Intelligence, was asked for a report on the need for heavier guns against the protection of new foreign battleships. A definitive report that the heavier guns were necessary to retain combat effectiveness finally convinced the Board of the need for the heavier gun. However, not all the six inch QF guns would be replaced by the larger guns – some would be retained.\(^\text{437}\)

The Board refused to consider any significant reduction in capabilities which would have been required if the new, larger guns were used on the standard pattern ship.

\(^\text{436}\) Ship’s Cover, *King Edward VII* Class, NMM.

\(^\text{437}\) Ship’s Cover, *King Edward VII* Class, NMM.
Thus, the Board was finally forced to accept a larger ship. It reached a consensus at a meeting on October 10, 1900 that the regular draught could increase to 15.5-16,000 tons and the deep load draught would be allowed to increase to 17 thousand tons. While weight was always the headline limit on what equipment a ship might carry and where it was located, space, especially space under protection (e.g. the armored deck), was also an issue. In order to fit in all the desired equipment and optimize stability and hydrodynamics (how the ship moved through the water), the ship was lengthened by 20 feet and 3 feet were added to the beam.

At this point, the real debates began. The Board allowed for a larger ship, but it was not much larger and the desired armament, armor and engineering plant did not fit well. Trade-offs still needed to be made but compromises between the elements were difficult. Beyond the idea that this new ship was to be “better than any other ship, ours or others,” there was nothing remotely resembling a consensus on what the optimum configuration of the ships needed to be to be the “best” ship afloat. There were too many variables and too much difference of opinion.

The Loss of the Guiding Hand: the Fall of William White

The guiding hand of British ship design, DNC William White, who was previously so important in creating agreement, was no longer able to lead the Board of Admiralty. White was aging and suffered periodic bouts of ill health. He also maintained a

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438 Ship’s Cover, King Edward VII Class, NMM.

439 Ship’s Cover, King Edward VII Class, NMM.
punishing schedule. The Constructor’s office, like most others at the Admiralty, was understaffed, a condition later acknowledged by the Admiralty. White also devoted long hours to his involvement with his professional associations (Institution of Naval Architects, Institution of Marine Engineers, etc) where he often served in a leadership role, and numerous consulting projects. The final straw for White, which broke his health, his confidence and damaged his reputation, was the fiasco of the new Royal Yacht, *Victoria and Albert*. The ship was fitting out in dry dock in January 1900 when it heeled over twenty degrees and was in danger of collapsing into the dock. The cascade of problems began with errors in calculations of stability by White himself and were compounded by numerous additions made to the ship’s fittings. These were mostly luxuries added for the benefit of the Queen and the Royal family, but there were many of them, and they added significant weight to the vessel. Worse, the additions were on the upper decks, “up high,” which was particularly problematic for stability. Finally, the ship was fitting out in dry dock instead of floating in a finishing berth, where the problems likely would have become evident before they became nearly catastrophic. None of these problems was caught and disaster struck.

440 “Reports of the Committee to consider the Organization and Working of the Departments of the Director of Naval Construction and Engineer in Chief,” 1901, The National Archives: Public Record Office (TNA:PRO) ADM 268/3.

White’s health collapsed.\textsuperscript{442} He suffered a nervous breakdown and took a six month leave beginning in the spring of 1900. Much of his energy before he left and after he returned was devoted to investigating the accident or cooperating with an Admiralty investigative committee, which issued its report in July of 1901. White also became indecisive in the office and obsessed with minor details.\textsuperscript{443} Finally, his reputation as a shipbuilder suffered badly. Questions were asked in Parliament about his performance and fitness to continue in the employ of the Navy. While many key figures still supported him, including former First Lord Goshen, confidence in his decisions was undermined in many quarters.\textsuperscript{444} All of this sapped his ability to take the lead and steer the Admiralty into a consensus compromise and he resigned by the end of 1901. White’s leadership evaporated at a time it was badly needed.

\textit{No End to the Debates}

The Board began to tackle the details of squeezing all the desired capabilities into a larger, but still too small, ship without leadership and without a clear general agreement on priorities. This first issue after guns and size to become a source of contention was armor. White’s initial sketch design, submitted in October of 1900 after he returned from leave, included some tinkering with the armor layout from the London class, but only included minimal changes. While most of the Board approved, Controller A. K. Wilson

\textsuperscript{442} Manning, pp. 428-429, 445-449.

\textsuperscript{443} Manning, p. 431.

\textsuperscript{444} Parke\textsuperscript{s}, p. 347.
characteristically opposed any changes. Competing armor schemes from White and Wilson were circulated. Both drew support, and discussion surged back and forth. An increasingly common Board conference was held to discuss the issue. Second Naval Lord Douglas and First Naval Lord Kerr went so far as to propose to wait and see how other details of the design worked out before making a decision.\footnote{Ship’s Cover, \textit{King Edward VII} Class, NMM.} The debates surrounding the design of this ship were so strong and so divisive that the two most senior officers in the Navy were advocating putting off a decision in the hope that something would allow for a consensus, or at least an accommodation, to emerge.

Two days later, the Board held another conference, and this time reached a compromise. However, that was not the end of discussions. The amount and arraignment of armor was reintroduced when the Board met in November to approve the placement of the six inch guns. To save weight, they were placed as a battery, instead of White’s favored casement.\footnote{Manning, p. 441.} Discussion then turned to other elements involved in armor protection, particularly in the bow and stern, that had been settled in October. This in turn meant that specifications of the armament and engineering plant, which had been established in October, came up for consideration again because of their weight and space implications. These debates played out in a series of meetings and memos circulated between the conferences that endlessly argued about what should be sacrificed to include what.\footnote{Ship’s Cover, \textit{King Edward VII} Class, NMM.}
In the spring of 1901, the design debates on the *King Edwards* continued in the same pattern as the previous fall. Squeezing the desired elements of the ship within the weight parameters dominated all discussion and still more adjustments were made. Fittings and stores were reduced, and ships’ boats were made smaller to save weight. In the fall, armament was again changed, this time on the suggestion of William White on his return from medical leave. He suggested that the 7.5 inch guns could be upgraded to 9.2 inches with minimal increases in weight and at little cost in stability—there were only four guns to upgrade, as opposed to fourteen.\(^{448}\) This was almost true. The weight situation for the *King Edwards* was so tight that the increase of 140 tons was difficult to accommodate. Changes were still being made to armor, and the size of the turrets was reduced to save weight. At this point the type of boilers to be used, which had weight and space implications and had been settled for the previous four classes of battleships built, became an open question. The details will be discussed below, but this dispute created more uncertainty and opened still further discussions of weight. Meetings and memos continued, as everyone had to get his opinion in on nearly every issue. The dockyards and Constructor’s office began to show signs of frustration, as the Board was constantly asking for design changes, which required design work from the office and complicated and delayed the actual work on the ships.\(^{449}\)

\(^{448}\) Parkes, p. 423.

\(^{449}\) Ship’s Cover, *King Edward VII* Class, NMM.
While the general lack of consensus and leadership vacuum were significant problems, the Controller, Admiral A.K. Wilson, needs to take a substantial share of the blame for the difficulties in reaching final decisions on elements of the King Edward VII design. The stubbornness he showed over the speed and amount of armor for the design manifested itself across the entire series of debates. Wilson argued many issues beyond the point where it was clear he was a small minority or a minority of one. He would concede at that point only with great reluctance, and not always even then. Wilson was the most likely to revive an issue that had been decided in an effort to change the outcome. Wilson kept coming back to armor and its disposition on any issue that had weight implications—which meant almost any issue involved in the design of the ship.450

Wilson’s reluctance to accommodate his colleagues was uncharacteristic of British naval officers at this time but it was a central aspect of his personality. A. K. Wilson had a long and successful background in one of the most technical fields of the Navy, torpedoes. He had served on the committee that recommended adoption of the Whitehead type torpedo in 1870, was the Assistant Director of Ordnance for Torpedoes from 1887-1889 and Captain of the Torpedo School, the HMS Vernon from 1889-1892. His role in the adoption of newer types of torpedoes while at the Vernon was recounted previously. In between, he won a Victoria Cross leading a naval brigade in the Sudan in 1884. He was, however, ill suited to the post of Controller. Wilson was not collegial and had a reputation as gruff, abrasive and stubborn. He was inarticulate and a very poor communicator who disliked debate or justifying his conclusions. Where he could, as

450 Ship’s Cover, King Edward VII Class, NMM.

\textit{The Battle of the Boilers}

While the seemingly endless debate on the overall design of the King Edwards raged, a controversy about ship’s propulsion systems was reaching a boiling point. Starting with the \textit{Canopus} class of battleships in 1896 the Royal Navy had adopted water-tube boilers to provide steam to drive the ship. However, maintenance issues were common because the technology was still relatively new. The Navy was still learning how to manage it properly and breakdowns were common. The resulting controversy, dubbed the “battle of the boilers” emerged at about the same time though independently of the design controversies surrounding the \textit{King Edward VII}s. Arguments over the types of boilers used for battleships raged for over two years. It further complicated the design of the
King Edward VIIIs indirectly because the types and number of boilers had weight and space implications, which greatly impacted the general arguments over the design. The controversy also marked perhaps the most extreme descent into incivility and controversy over naval technology, with disputes over the reliability of evidence, name calling and accusations of bad faith marring the proceedings.

As discussed earlier, Belleville water-tube boilers had been adopted for use in the Canopus class, the first ships of which had been laid in 1896. However, water-tube boilers still had teething problems that had to be overcome. They were significantly more difficult to maintain and engineers with little experience and no official manual were not able to keep them running efficiently.453 While the machinery required less water within the system to operate, which saved valuable weight, Belleville boilers consumed more water than older tank style boilers and increased machinery was needed for evaporators, which distilled seawater, and more coal was needed to run the evaporators and the boilers on low power even when the ships were not moving. They also used a greater amount of coal underway. This came as something of a surprise to most, as trials had suggested the opposite.454 A few observers, however, were well placed to say “I told you so,” as they had challenged the accuracy of the trial efficiency,


observing that picked coal and crews were used, and that the boilers would be less
efficient under normal usage.\textsuperscript{455}

Admiral W.H. May later argued that Engineer-in-Chief Durston and Admiral
Fisher, then Controller, rushed the Belleville boiler into service without adequate trials.\textsuperscript{456}
May, however, disliked both Durston, who he viewed as obstructive of new ideas, and
Fisher, whom he regarded as self-centered and self-promoting.\textsuperscript{457} Note, too, that May
absolved White, a strong advocate of the use of Belleville boilers whom May respected
enormously, from blame. May was possibly correct that more thorough trials, probably
with larger ships, should have been held before Belleville boilers were fully adopted. A
more gradual introduction might have saved a great deal of trouble later. However, the
blame needs to be spread more widely than Durston and Fisher, as very few had anything
but praise for water-tube boilers and confidence that they would be successful.\textsuperscript{458}

\textsuperscript{455} W.H. Moss, discussion of papers “Recent Trials of Cruisers Powerful and Terrible”
and Water Tube Boilers in Warships,” \textit{Transactions of the Institution of Naval Architects},

\textsuperscript{456} May, Sir William H, \textit{Memoirs of Admiral of the Fleet William H. May, GCB, GCVO,
1863-1930} (London: William Clowes and Sons LTD, 1934), p. 72, printed for private
circulation, call number 92 MAY, Item ID PBD6129, National Maritime Museum,
Greenwich, p. 65.

\textsuperscript{457} May pp. 65, 68.

\textsuperscript{458}“Introductory Remarks” by Institution President the Earl of Hopeton, pp. 146-147, and
papers “Recent Trials of Cruisers Powerful and Terrible” and Water Tube Boilers in
By 1900, criticism of Admiralty use of Belleville boilers had reached the press in
the magazine *Engineer* and Sir William Allen attacked them in Parliament.\(^{459}\) Under
pressure, the Admiralty convened a committee to examine the boiler issue in September
of 1900. The Committee on Naval Boilers, like the previous Committee on Machinery
and Boilers, was mostly made up of technical experts from outside the Navy. Admiral
Compton Domville, the President, was the only naval officer and Joseph A. Smith, Chief
Inspector of Machinery was the only other naval employee on a committee of eight. It
was charged with generally determining whether water-tube boilers were suitable for
naval use and, if so, whether Belleville boilers or some other type of water-tube boiler
might be the best available.\(^{460}\)

Parkes, in *British Battleships*, the standard reference work, is very critical of
opponents of water-tube boilers because he thinks tank boilers had reached their limits
and it was obvious that water-tube boilers represented the future.\(^{461}\) He lays most of the
blame on the uncritical acceptance of the known and the unreasonable overreaction to
new difficulties: “It is sea-going human nature patiently to suffer accustomed evils, but to
be very intolerant of new difficulties; hence what might be only a trifling and remediable
defect in a water-tube boiler would be regarded as outweighing all the long-standing

\(^{459}\) Parkes, p. 393.

\(^{460}\) Boiler Committee Reports, TNA:PRO ADM 116/635 and ADM 116/869 through
116/872 for the Committees charge, a full list of members, minutes of meetings, full data
on trials, correspondence and interim and final reports.

\(^{461}\) Parkes, pp. 393-394.
troubles experienced with the older type.\textsuperscript{462} Parkes implies other critics were unthinking reactionaries. He refers to Allen as a member of the “old guard” and suggests that much opposition came from boiler makers who did not wish their costly industrial plant to become obsolete.\textsuperscript{463} Indeed, one of the few voices raised against water-tube boilers at the 1897 INA meeting was James Howden, an inventor of a system of forced draft, which forced air into the combustion chamber to create a more intense fire and more steam, that would become obsolete with water-tube boilers.\textsuperscript{464}

However, most of the problems experienced by water-tube boilers were real. Water-tube boilers were complex machines and the Navy had little institutional knowledge of how to deal with them. Manufacturing the tubes so that they could withstand the heat and high-pressure steam without corroding and leaking was very difficult, particularly for the connecting joints and only gradually mastered. The solutions to older problems with tank boilers were known and could be methodically applied; solutions to the new problems with water-tube boilers were not. As manufacturing quality improved and more experience gained, the number and severity of problems dropped and delivered the promised benefits without imposing unexpected costs.\textsuperscript{465} This took time, however, and it is only obvious that it would happen in hindsight.

\begin{footnotesize}
\begin{enumerate}
\item Parkes, p. 393.
\item Parkes, pp. 393-394.
\item W. H. Moss, \textit{Trans. INA} 1897, pp. 189-192.
\item Brown, \textit{Warrior to Dreadnought}, p. 165.
\end{enumerate}
\end{footnotesize}
The Committee’s work was thorough. It carried out extensive trials with two second-class cruisers, the Hyacinth with Belleville boilers and Minerva, outfitted with cylinder boilers. It collected lists of defects reported by Belleville equipped ships, and inspected over two dozen ships with Belleville and tank boilers. It examined months of logs of coal and water consumption in different ships. It later ran trials using sloops and other cruisers employing various alternative water-tube boiler designs and investigated over a dozen others. It had boilers of types that were not utilized by the Royal Navy installed in two ships specifically for trial. It inspected boilers on merchant ships and took testimony from marine engineers. It went so far as to visit Paris and Marseilles and discussed boilers with the German and Austrian naval attachés.466

All of this led to a series of reports that did much to set boiler policy through to World War I. An interim report issued in February of 1901 stated unequivocally that water-tube boilers were superior to tank boilers for military purposes “providing a satisfactory type of water-tube boiler be adopted.”467 It would not, however, recommend Belleville boilers as the most suitable type. The installation of Belleville boilers was suspended pending further review, but the Committee did not condemn them outright.


The next report, the interim final report, was not as kind to Bellevilles. The Committee established criteria defining a satisfactory water-tube boiler. While the Belleville met this criteria to the satisfaction of the Committee, it found Belleville boilers were sound when new but deteriorated rapidly with use, had numerous other technical problems that offset its advantages and Bellevilles required exceptional experience and skill to operate and maintain, all of which made them unacceptable.

The Committee further found that water-tube boilers which used small tubes were acceptable only on small ships. Bigger ships would need large tube boilers and concluded that four types, Babcock and Wilcox, Yarrow, Durr, and Niclausse were worthy of attention. However, it would not make a recommendation as to which was best. It looked forward to the installations on all types of boilers on various ships of the *Monmouth* and *Devonshire* class cruisers, some of which also had Bellevilles, and stated only “prolonged use” and “lengthened experience” would be able to answer the question as to the most suitable type.

Finally, the Committee noted that there were no water-tube boilers yet available which were as economical as cylindrical boilers. Thus, it recommended that ships have

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468 The Committee issued a report, contained in TNA:PRO ADM 116/635, in May of 1902 which it characterized as “nearly as final as the circumstances of the case will permit,” leaving only the issue of a recommendation as to the best overall type of water tube boiler until the “final” final report in 1904.


mixed batteries of boilers in an attempt to combine the best features of both types. Cylindrical would be available for low power cruising and to provide power in port; water-tube boilers would be available to rapidly increase power in emergencies and to provide full power for war operations. The Board opposed this—they wanted all water tube boilers—but First Lord Selbourne, who replaced Goshen in 1902, endorsed the report and mandated that mixed installations proceed. It was unusual for the First Lord to override the united opinion of his naval advisors on the Board on technical matters. In this case, however, Selbourne could point to support from the findings of the Committee and his decision was probably related to the political circumstances which surrounded the establishment of the Committee in the first place. The immediate result was that most of the ships of the King Edward VII class had mixed boilers fitted—some cylindrical and some water tube. This compromise did not last—only the King Edward VIIIs and a few classes of cruisers were fitted with the arrangement, which was discontinued as soon as the controversy subsided. Then, water tube boilers quietly returned as the standard.

The report of the Committee did not quiet the debate over boilers but rather created the explosion of a new controversy. This was highly unusual. The findings of expert technical Committees were generally respected and their recommendations adopted as naval policy. Engineer in Chief A. J. Durston responded to the report with a

fifteen page rebuttal of its findings. Durston was harshly critical of the Committee. His primary claim was that the Committee was biased against the Belleville boiler, though he never suggested what motivated such bias. He argued that the Belleville met the conditions set forth by the Committee for an effective boiler and that its disadvantages were no greater than any other type. It is only “the opinion” of the Committee that its “advantages are counter-balanced by its disadvantages.”

Durston argued that the Committee made errors of fact by attributing faults to Belleville boilers that were either universal to all water-tube boilers or the result of inferior materials, which he argues has nothing to do with the merits of Belleville boilers. Further, he contended that the Committee’s methodology, particularly in testing for the fuel efficiency of boilers, was faulty. It ignored the relative quality of coal and different nature of operations of Belleville and cylindrical boilered ships, he claimed. Finally, he argued that a number of special cases, including the Glory, a Belleville boilered Canopus class battleship whose chief engineer was court-martialed for negligence, needed to be deleted from the data for accurate results. Essentially, he contended that the Committee failed, perhaps willingly, to control for variables that had an impact on boiler function and efficiency, and therefore got erroneous results.

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472 The “Report of the Committee on Naval Boilers, TNA:PRO ADM 116/365, contains, in addition to the Committees interim final report, Durston’s memo, the Committees response to Durston’s memo, Durston’s further response, and discussion by the Board.


The Committee responded with its own letter, claiming that proper control had been placed on extraneous variables, that it had made no errors of fact and that its opinions were founded solely on the data available to it. It pointed out the positive results of adherence to several of its recommendations, to reinforce its credibility. It restated a number of comparisons in ways demanded by Durston and still drew the same overall conclusions. The Committee stood by its findings.475

The Board was not pleased with this controversy, and just wanted it terminated. Controller W. H. May was willing to concede that Durston had made some valid points and was willing to include his memo as an appendix to the final report, along with the Committee’s rebuttal. May even agreed with Durston’s opposition to mixed cylinder and water-tube boiler installations. However, he endorsed the Committee’s report in order to finish the discussion and end the controversy. The rest of the Board who responded, including First Naval Lord Kerr and First Lord Selbourne, concurred.476

Controversy of this type was unusual within the Navy. The Financial Secretary, in a memo concurring with the Board’s decision to endorse the report, including Durston’s critical memo, and end the discussion, noted with distaste Durston’s implication that the Committee was not competent.477 The close knit environment of the


Navy, where an officer might serve with another intermittently for years, encouraged moderation in argument and acceptance of defeat as both good sportsmanship and a practical means of preserving relationships. Durston did not display moderation.

**Still a Problem: Nitrocellulose Propellant, part 2**

A second issue that took the time and attention of the Admiralty during these years was the subject of the Navy’s smokeless nitrocellulose propellant, cordite. To review briefly, nitrocellulose based compounds had replaced black powder, old fashioned “gunpowder,” in the early 1890s. Nitrocellulose powders imparted higher velocity while producing far less residual smoke, hence the name “smokeless.” Numerous different varieties of the new nitrocellulose based propellant were rapidly developed as military organizations and their suppliers sought an optimum formula. Some of these compounds also included nitroglycerin with the nitrocellulose. Cordite was one such compound and also the one developed for and adopted by the British military.478 Significant disagreement developed between the Navy and Army over efficacy of cordite as propellant for guns. It should be recalled that the Navy had a difficult time in its interactions with the Army when cordite was developed as the British military’s nitrocellulose “smokeless” propellant in the first place. These differences were closely tied with larger issues over ordnance development delays and the Navy attempting to regain control over its own ordnance. New issues emerged within a few years after

478 Please see chapter 3 for details.
cordite was brought into use by the Navy (and Army), which continued the conflict over the control of ordnance and the Navy getting its needs met.

The Navy had never been happy with cordite. An 1898 report outlined cordite’s defects, which included inconsistent ballistics, that is unpredictable variation in the speed at which the shell left the gun, and thus range and penetrating power of the shot, which were caused by variations in temperature, deterioration of cordite in hot climates and excessive erosion of the gun tube.\textsuperscript{479} A 1900 report from Naval Intelligence indicated most foreign navies were using some form of ballistite, another smokeless propellant that differed from cordite in that it was made from nitrocellulose and did not contain nitroglycerin. Another report on French armament the same year concluded that it was in no way superior to British, except for propellant (polycollidon – a variant of ballistite), which was rated as better.\textsuperscript{480} Requests to the Ordnance Committee for experiments to find an alternative were dismissed because War Office chemists thought cordite was better than any other propellant available.\textsuperscript{481}

In growing frustration, First Naval Lord Kerr requested that First Lord Goshen send a letter to the War Office to bring pressure to bear at the highest level. Goshen’s

\textsuperscript{479} Minute from Director of Naval Ordnance, April 1900, citing a report by the Navy to the Ordnance Committee in November 1898, TNA:PRO ADM 256/36.

\textsuperscript{480} Minute from Director of Naval Ordnance, April, 1900, citing a report by the Naval Intelligence Division, May, 1899, TNA:PRO ADM 256/36.

\textsuperscript{481} Minute from War Office to Director of Naval Ordnance, April 1900, TNA:PRO ADM 256/36.
letter was far more gracious that his subordinates were feeling. It outlined the Navy’s position and it offered to share the cost of an additional researcher.

This letter prompted the Army’s Director General of Ordnance, who had already begun exploring the need for further research into propellants, to propose the formation of a Special Committee on Explosives to the Secretary of State for War in April 1900.482 The Committee consisted of several prominent scientists, including Sir Andrew Noble, who had long worked on ordnance issues, Richard Haldane, an M.P., and Captain T. G. Tulloch of the Royal Artillery as Secretary. Noble was one of the fathers of scientific internal ballistics. He was a first rate scientist, whose experimental work on the decomposition and properties of black powder is still definitive. The Committee was initially to hire one working chemist, but quickly added an additional chemist and two assistants. The Committee’s instructions included trials to find the best smokeless propellants for use in guns and small arms, recommend any modification of gun designs needed to most effectively use whatever propellant was settled on, and to carry out trials to find a better high explosive than Lyddite for all types of guns.483

The Committee’s basic charge was satisfactory to the Admiralty.484 It wanted an investigation of alternatives to cordite, was not averse to recommendations for

482 Report of the President, Explosives Committee, “Business of the Committee,” p. 13, Records created or inherited by the Ministry of Supply and successors, the Ordnance Board, and related bodies, TNA:PRO SUPP 6/526.

483 Report of the President, Explosives Committee, pp. 5-8, 13, TNA:PRO SUPP 6/526.

484 Minute endorsing War Office proposal of committee on explosives TNA:PRO ADM 256/36.
improvements in guns, and distrusted the safety of lyddite as a high explosive in shells. However, nothing else about the Committee really met the Navy’s needs. The Committee was under the complete control of the War Office and reported to the Director General of Ordnance and Secretary of State for War. An Army officer in the Royal Artillery was the Secretary. The Committee’s charge, while it addressed useful issues, was imperfect from the Admiralty’s point of view as well. The investigation of propellant for small arms were a distraction from the Admiralty’s needs, and while an alternative to lyddite was welcome, it was not what the Admiralty was looking for when it pressed for more research. Finally, while pressure from the Admiralty augmented the reasons for creating the Committee, the War Department had its own reasons for further investigation of propellants and explosives, and its dominance of the Committee ensured that its priorities would dominate the work of the Committee.

An Admiralty letter to the Committee asked for something, anything, that was better than cordite. The letter specifically requested trials of improved ballistite and pyrocollodion, the two most important alternatives to cordite. The Admiralty’s position encountered immediate difficulty with the War Office. Colonel Ormsby, Superintendent of the Royal Gunpowder Factory, in response to the Navy’s list of the defects of cordite, questioned whether the Navy’s complaints were legitimate. He asked if there was any real evidence the cordite caused too much erosion of gun barrels or that its ballistics

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485 Series of memos between the DNO, First Naval Lord, First Lord and War Office, from November 1898 to May 1900, TNA:PRO ADM 256/36.
varied significantly with temperature, implying that there was not. Further, he denied
that cordite deteriorated with heat. 486

The Explosives Committee acted quickly. By the summer of 1901 it had issued a
favorable report on rottweil, a ballistite variant, though it recommended further
experimentation. By the fall of 1901, just over a year after its formation, it issued a
report on modified cordite, subsequently known as cordite MD. Cordite MD greatly
reduced the proportion of nitroglycerine to 30%, as opposed to 58% in cordite, and had a
correspondingly higher proportion of nitrocellulose (gun cotton), up to 65% from 37%. It
burned cooler, which reduced gun wear, and its ballistics were sound. 487 The Committee
also pronounced it stable, while at the same time doubted the stability of single-base
nitrocellulose propellants like those used by the French. Further trials were undertaken,
including some competitive trials with rottweil, which were carried out in 1902. Cordite
MD was approved by the Committee for use by the Army and by the Navy for guns of six
inches and less before the end of the year. Adoption for larger guns would occur after
trials to determine proper charge sizes. 488

By the end of 1901, the Committee was urging the formation of a permanent
experimental establishment. Both the War Office and the Admiralty were
enthusiastically in favor of it and agreed to fund half of the experimental establishment.

486 Explosives Committee Reports and Programs, “Defects of Cordite,” pp. 7-8,
TNA:PRO SUPP 6/513.


488 Explosives Committee Reports, “Report Number 2,” pp. 22-24, TNA:PRO SUPP
6//513; Reports of the President, Explosives Committee, p. 10, TNA:PRO SUPP 6/526.
In addition an officer from each service was appointed as an associate member of the Committee. The Committee’s purview was expanded to include general research on all types of explosive, and to coordinate with the various manufacturing facilities as needed. The Explosives Committee essentially became the general explosives R&D arm of the British military.\textsuperscript{489}

However, by 1903 the Admiralty was once again frustrated by the apparent lack of effort to find or develop an alternative to cordite other than cordite MD. The DNO sent a memo to the Explosives Committee requesting more testing of alternatives to cordite, especially nitrocellulose powders, and even offered to provide the funding. The Committee insisted that its findings and its interpretations of foreign studies demonstrated that cordite MD was better, and the DGO backed his Committee. The DNO and Admiralty had little alternative but to acquiesce.\textsuperscript{490}

The Navy did have two potential alternatives, turn to the private sector or build its own facilities, but did not pursue either one for reasons of lack of institutional flexibility and cost. The private sector provided guns, armor, machinery and other engineering needs.\textsuperscript{491} However, the Admiralty seemed reluctant to embrace the private sector for its chemistry, as opposed to engineering needs. Many private individuals and organizations

\textsuperscript{489} Reports of the President, Explosives Committee, “Instructions,” pp. 5-8, TNA:PRO SUPP 6/526.

\textsuperscript{490} Reports of the President, Explosives Committee, pp. 20-22, TNA:PRO SUPP 6/526.

approached the Navy in an attempt to convince it to adopt their propellants, but few were given exhaustive tests and many were summarily dismissed. There was significant distrust of outsiders in general and profit-driven companies in particular. The private sector had long provided machinery and Fisher, when DNO and Controller in the 1890s, had worked to develop firms as supply sources for guns. However, he was a highly unusual naval officer who had connections in industry and was willing to work with it to get what he wanted. No other officer of similar imagination and willingness to be different emerged to push through similar arrangements with industry for propellant.

There also appears to have been no interest within the Navy in setting up its own facilities. Cost was probably a factor here. It would have been very difficult to convince a frugal Parliament of the need to fund a parallel establishment to that of the army. Such an establishment would have been widely perceived as redundant. Similarly, the Admiralty was unlikely to switch significant resources to such an establishment. Budget setting already involved serious compromises and a completely new establishment would have entailed unacceptable cuts elsewhere. Lack of imagination within the Navy and budgetary constraints continued to limit the Navy’s ability to get the weapons it wanted.

492 The Navy received all sorts of proposals offering it new equipment of one sort or another and most of the ideas were readily identifiable as ridiculous and clearly not worth the resources to investigate. See, for example, Correspondence digest for 1900, index code 90, miscellaneous science, code 91, Her Majesties ships and vessels, code 92, offers for sale, code 91a, machinery: inventions, and 91a2, machinery: inventions: fuel, TNA:PRO ADM 12/1357.

493 Sumida, *In Defense*. Sumida discusses the many problems Arthur Pollen had in convincing the Navy to adopt his fire control system, one of which was the hostility to him as both an outsider and as businessman.

In fairness to the War Office, the Ordnance Committee, the Explosives Committee and the various individual partisans of cordite, they were probably correct that cordite was at least as good, if not better than, any of the alternatives available. The French poudre b, pollycollidon, which the Admiralty thought superior to cordite, did not store well and deteriorated significantly with age. The French lost two battleships, the *Iéna* in 1907 and the *Liberté* in 1911 to magazine explosions attributed to the deterioration of the powder and its resultant instability, hardly a ringing endorsement of pollycollidon. Cordite itself did cause some problems during World War I, most spectacularly the loss of the *Vanguard*, a *St. Vincent* class dreadnought, in 1917. However, changes in the manufacturing process and formulation, initiated before the loss of the *Vanguard* but not yet manufactured in quantity, addressed stability issues. Further changes in cordite followed during the inter-war years and a third nitrogen-based explosive, nitroguanidine, which was nitrated guano, was also added to cordite and used during World War II.\(^{495}\) These changes took substantial additional research stretching over decades, which indicates that they were beyond the ability of contemporary chemists and chemical engineers to make and produce in industrial quantities.

Essentially, the Royal Navy had a product that was about the best available at the time but it did not believe it. The War Office was unwilling to work to prove the efficacy of cordite to the Navy’s satisfaction. The War Office ignored repeated requests from the Navy for further aggressive research which, in addition to the long history of acrimony between the two organizations on issues of ordnance, left the Navy

\(^{495}\) Campbell, pp. 139-140.
unconvinced that cordite was of suitable quality. The Navy was somewhere between unwilling and unable to undertake the process of development of a new propellant itself, which left it no choice but to accept what the War Office was willing to give it.

*Continued Tension and the Lord Nelson Class*

The design of the *Lord Nelson* class did not proceed any more smoothly than the *King Edwards VII*s, though the finished product was superior. The process was characterized by the same difficulties that plagued the King Edward VII*s, the desire for more capability combined with incompatible size limitations, interminable discussions over decisions, lack of leadership and a difficult individual in a key role. The level of outright hostility that characterized some of the discussions on the *King Edward VII*s and the boiler controversy was missing. However, the deliberations were not the friendly search of consensus that characterized most of the 1890s, either. The saving grace lay in studies on the relative merits of different sizes of guns and effectiveness of armor protection, which the Board, continuing to show its respect for quantitative information, used to inform its decisions.

Despite the lesson that heavier armament entailed unacceptable sacrifices in other capabilities or a larger ship, the initial specifications for the new class called for a return to the standard size ship of 14,000 tons regular draft but with the same armament, speed and protection of the *King Edward VII*s. This utterly ridiculous proposal was impossible and the Board should have known better than to have wasted its time on it. The Board was almost the same – the only naval member of the Board to have changed was Admiral
Wilson, the Controller, replaced by the far more capable Admiral W. H. May. That they would even bother to ask for such a ship is an indication of a lack of clear thinking and while the idea was quickly dropped, it was evidence that the Board still had no coherent idea of what it wanted beyond “everything.” Rapid acknowledgement of reality did follow quickly, though the Board allowed for only 1000 tons more than the King Edward VIIIs and limited the ships to the same length and beam, which created problems fitting everything into the allocated volume.

The design was also a year late. The excuse given later is that the Admiralty wanted a coherent squadron of eight ships and so decided to delay pursuing any new design. While coherent squadrons were regarded as valuable, it is difficult to disagree with Parkes’ assessment that any Board that would willingly give up so much additional firepower (looking ahead to the increases in the Lord Nelson class) just to create a squadron was criminally negligent. Parkes claims that the dockyards had proved so quick in building earlier ships that it was necessary to get them work at once to avoid layoffs and as the new design was not ready yet, three more King Edwards were made part of the 1903 budget and begun in early 1904.

Parkes’ reasoning appears flawed, however. The launch dates of the King Edward VII and the Zealandia, constructed at the Devonport and Portsmouth dockyards

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496 Ship’s Cover, Lord Nelson Class, NMM.

497 Parkes, pp. 452-453.

498 Parkes, p. 426.

499 Parkes, p. 426.
respectively and launched by the end of July 1903 and in February 1904, were reasonably consistent with this claim. However, as of 1904, the last battleship launched by the Chatham Dockyard was the *Prince of Wales*, a *London* class ship completed in early 1902, almost two years earlier. No First Class Cruisers, which would have been large enough to occupy a comparable portion of a dockyard’s efforts, were completed at Chatham in the 6 months prior to early 1904, either.\(^{500}\) So this reason does not seem quite right.

It is certainly true that the new ship design was not ready. The process of determining the design of the *Lord Nelsons* was as long and drawn out as that for the *King Edward VII*s. Meetings and memos were endless, and showed a similar level of contentiousness. Either the Board was more aggressive about taking minutes of meetings and saving memos or discussions were becoming longer and increasingly complex and disagreements were harder to resolve.\(^{501}\) Given the original specifications it is clear that the Board wanted it all, firepower, protection, and a small, (relatively) inexpensive, ship. This was simply not possible within the bounds of physics but the Board had no consensus on priorities and therefore no real means of hammering out broadly acceptable compromises without very extensive arguments. The details of portions of the design were debated endlessly as a result. For example the 9.2” guns and their mountings, including how many and where they were located on the ship, were the subject of four

\(^{500}\) *Conway’s*. pp. 37-38, 68-72.

\(^{501}\) Compare the Ship’s Covers, which contain a record of the deliberations on the design and construction of a class of ships, of the *Lord Nelson* Class and the *King Edward VII* Class with those of earlier battleships: the *Duncan* Class, the *London* Class, etc. NMM.
conferences alone, despite the fact that the need for 9.2 inch guns was unanimously accepted.\footnote{Ship’s Cover, \textit{Lord Nelson} Class, No. 197, NMM.} The self-imposed limits on the size of the ships meant that every decision had weight and space implications that had an effect on other systems. The Board and others concerned with ship design (e.g. the DNO, the Engineer in Chief) could not easily reach a consensus on the specifications for the ship in part because ramifications of every decision touched on areas in which someone held strong views. This meant that not only did an agreement on a particular item, such as the type of gun mountings, needed to be made, but that other issues which the weight and location of the gun mountings had an impact needed to be addressed, at least tentatively. For example, as weight devoted to armor, and therefore to the details of armor arraignment, had to be dealt with, at least tentatively, to reach an agreement on the initial decision, in this case the gun mountings for the 9.2 inch guns. This slowed the design process.\footnote{Ship’s Cover, \textit{Lord Nelson} Class, NMM.}

In addition, there was friction between the DNC, Phillip Watts and the Board, particularly the Controller, Vice-Admiral William May.\footnote{May, p. 72.} Once the basic parameters of a design were established it was the responsibility of the DNC to create a design that more or less met them. Among the design parameters set by the Board was that the ships fit within docks at Chatham and Portsmouth. Watt’s initial efforts did not, so the Board angrily told to him redo his work.\footnote{Parkes, pp. 452-453.} In Watts’ defense, he does appear to have had
conversations with May about his ideas but since May was very unhappy it would appear that Watts was not given approval for departing from instructions. Also, to a certain extent, the Admiralty might have been spoiled by William White, who—at least until his breakdown—could not only brilliantly accommodate Admiralty requirements, but also was often able to subtly steer the Admiralty into wanting what he could produce. In addition, as the Board did not know what it wanted, or rather it desired everything and did not know how to prioritize, it is perhaps unfair to hold Watts responsible for increasing the size of the ship to make everything demanded by the Board “fit.” Again, this does not excuse Watts as he veered too far from Admiralty instructions. In any case, the need to repeat the work was instrumental in creating significant delay in a process that was already moving slowly and could not afford more problems.

The first major decision needed, after the realization that the ship could not be made to fit into the desired size limits, was the type of armament. Many circumstances ultimately pushed the Admiralty to wish for even heavier armament than the King Edward VIIs. Broadly, the reasons were similar to the reasons that drove the push away from the standard model armament in the King Edward VIIs – the concern that heavier armament was needed to match foreign ships and that improving armor on foreign ships would render six inch guns ineffective. This reasoning was supplemented by some serious thought about the implications of the rapidly growing range at which battles were expected to occur and a detailed analysis of gun capabilities verses strength of armor, particularly at longer ranges.
A few technical explanations are in order to properly explain the implications of this expected increase in the ranges at which battle would be fought. The last years of the 19th and early years of the 20th century were a time of rapid change in the effective range of naval gunnery. Naval gunnery had an effective range of less than 2,000 yards until almost 1890. Ranges were short not only because of the limitations of the guns and gunpowder but because the rapid and chaotic movement of a ship through three dimensions (and time) made aim difficult even at short ranges and rendered the chance of hitting at higher ranges negligible. Guns were fired more or less horizontally and flight times of shells were very short so there was little need to find the range in order to set the elevation of the guns. Methods to improve aiming at longer ranges were sought beginning in the late 1880s and early 1890s. Torpedoes, which though still short ranged in 1890 (1,000 yards at the most) showed rapid improvement in range and promised more, were the object of widespread concern. Interest was also spurred by the new nitrocellulose based propellants, which also promised more range. Jon Sumida also suggests that the high rate of fire of new quick firing guns contributed to stimulated interest in longer range shooting.

As a result of increasing interest and need, a number of devices and techniques to find ranges and improve aim were introduced by 1904. The Bar and Stroud stereoscopic

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507 See chapter 3 for the Royal Navy’s efforts to secure a range finder in the 1889-1893 period.

range finder, the earlier versions of which took accurate ranges up to about 4,000 yards, was adopted by the Royal Navy as a result of its search for a range finding device and was in general use by 1899.509 In 1902 Lieutenant John Dumaresq invented a slide rule type instrument which calculated the rate of change of a target’s range.510 Captain Percy Scott developed new aiming techniques for quick firing guns. He installed telescopic sights and altered the gear ratio of the elevating mechanism of the gun to make it possible to track a target through the movement of the firing ship and gun. This allowed for better aiming and a rapid increase in aimed fire.511 Experiments by officers of the Mediterranean Fleet with salvo fire, that is the firing of multiple guns at the same target at the simultaneously, found that it was possible to determine accuracy at ranges of 5,000 to 6,000 yards by sighting the splashes. Groups of splashes that were either long or short indicated incorrect range; splashes that bracketed at target, falling both just a little long and a little short, indicated the proper range and also likely unobserved hits.512 Effective range had roughly tripled though the equipment and techniques of long range naval gunnery at sea were still in their infancy. While coastal defense gunners, firing from fixed emplacements, had mastered much of the needed knowledge and technique to fire accurately at long ranges, hitting a moving target from a moving platform, that is a ship, was at least an order of magnitude more difficult and yet to be mastered.


510 Sumida, In Defense, p. 73.


Longer ranges began to prompt thinking regarding the relative effectiveness of large main guns, typically 12 inches, and smaller secondary guns, typically six inches (though now often changing to eight), on battleships. Twelve inch guns obviously delivered more explosive to target, close to triple the amount delivered by a six inch shell, as explosive carried by a shell was related to the shell’s volume, not its diameter. Shells from larger guns also retained their initial velocity better, as larger shells would suffer significantly less loss of velocity as a function of range than the smaller one. That is because of the higher ballistic coefficient of the larger shell, which is, the ratio of mass to diameter. In simple terms, the mass of the shell varies with the diameter cubed while the aerodynamic drag varies with the diameter squared. Larger shells arrived at the target faster and combined with their size meant they hit with much higher energy levels, which in turn delivered better armor penetration. However, six inch guns also had a significant advantage (beyond the fact that they were smaller and cheaper, so more could fit on a ship) their rate of fire, which, for quick firing (QF) guns, was as high as six shots per minute. Thus, main guns delivered more powerful blows but secondary guns meted out more of them. Even so, the rate of fire advantage for smaller guns was fading. The newest model 12 inch guns could fire one shot per minute, about twice as fast as the 13.5 inch guns of the Royal Sovereigns built for the Naval Defense Act of 1889. While six inch QF guns could still fire substantially faster, the difference was smaller and continued to shrink as ranges lengthened and gunners had to wait to spot the fall of shot from six inch guns to correct aim. Thus, the rate limiting factor for smaller guns was no longer the limits of the speed of loading and shooting. In addition, an issue that offset the rate of
fire advantage for the six inch QF guns was accuracy at long ranges. Twelve inch guns were also more accurate at longer ranges due to the lesser velocity at which six inch shells were fired and the inertial advantage of the larger twelve inch shell. The question became not rate of fire but rate of damage inflicted. Six inch guns could still fire more often and might still hit more frequently but not enough to offset the increased damaged caused by the 12 inch guns.

Two individuals conducted studies to determine the relative effectiveness of the two weapons. A series of studies was conducted by Captain H. J. May (unrelated to Admiral May, the Controller), Director of the Naval War College at Greenwich in 1902. Among other things, he compared the effectiveness of six inch guns vs. twelve inch guns at a range of 6000 yards. At that time it was considered long range but one at which May assumed firing would begin. At that range, six inch guns could not penetrate medium or thick armor – and were actually less likely to hit than twelve inch shells anyway. This confirmed that six inch guns were not effective against battleship armor, that they would not be useful until ranges were very short and that they were no longer useful as secondary armament on battleships, which were assumed to be for fighting other battleships. Guns larger than six inches were needed. There is no direct evidence that this influenced the thinking of the Board or others involved in the process of deciding the armament for the Lord Nelsons but it is very likely that at least some, if not all, of the concerned parties would have read the report and it is reasonable to assume that it affected the thinking of at least some of them.

513 Brown, Warrior to Dreadnought, p. 196.
A second study, sponsored by Admiral W.H. May, the Controller and carried out in part by the new Director of Naval Construction, Sir Phillip Watts, looked at the weight of ordnance delivered by different guns in a given time and the ability of armor to resist individual projectiles. It found that the rate of damage from a secondary battery of six inch guns, that is, its rate of hits and ability to cause damage with them, was less than that of the twelve inch main armament. So much less, in fact, that six inch guns could expect to be swept away by hits from heavier guns before they closed within effective range. It concluded that a secondary armament of six inch guns was of little value on a battleship and a larger caliber secondary armament was required.\textsuperscript{514}

With that information in hand, there was no question of using six inch guns, as in all previous battleships. Given that the 7.5 inch size for secondary armament had already been bypassed for the \textit{King Edward VII}s, the use of the 9.2 inch was a forgone conclusion. This, however, did not solve the problem of fitting the guns into the weight and space available. It took well over a year of meetings and discussions to finalize the number, mounting and protection of the guns. Several serious compromises were forced on the Board. First, instead of three double turrets per side (for a twelve gun total) the number was reduced to ten, with the mid-ship gun in a single mount turret. Watts and the Board clashed on this point, with Watts wanting to keep the extra guns. Unlike White, however, he failed to manage the Board to get his way and, indeed, did it so badly, he actually annoyed the Board, a mistake that White seldom, if ever, made.\textsuperscript{515} In addition, a

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\textsuperscript{514} Brown, \textit{Warrior to Dreadnought}, p. 181.
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\textsuperscript{515} Parkes, p. 452; May, p. 72.
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magazine had to be placed in a vulnerable position on the outer hull instead of deep inside. It was behind armor but the potential for disaster if it was hit was clear. Finally, the weight and space for the guns required compromises in other elements of the ships’ design.

W. H. May’s study was also instrumental in changing and improving armor. It established that much of the “thick” armor on the King Edward VIIIs was too thin to be effective against heavier guns. In addition, it made it clear that the King Edward VIIIs “thinner” armor needed to be upgraded to be effective against secondary armament in the five to eight inch size range. Of course, armor adds weight – and it was a significant ordeal to find “room” for that weight given the size limits on the ship and the myriad of other demands for capabilities. Given the results of the study, however, the extra armor, like the larger guns, was considered essential and “room” had to be found for it.

It should be noted that both of these studies, on guns and armor, show the Royal Navy grappling with new technology at a fundamental level. Recall that technology is not just the equipment but also the entire system surrounding the equipment, including how it is used. New equipment, better guns, torpedoes, and better armor, were driving changes in the combat environment. The Royal Navy reacted by studying the effects of these changes and then planning on how to change its tactical methods to maximize the efficacy of the equipment, both old and new. While it is clear the most of the officers of

516 Brown, Warrior to Dreadnought, p. 181.

517 Ship’s Cover, Lord Nelson Class, No. 197, NMM.
the Navy were not involved, enough were and at high enough levels that their efforts had an important influence on the Navy.

Experiments with Electricity

While the Board was deciding how to balance demands on guns, armor and size, it took some time out to discuss the potential role of another technology, electricity, in battleship systems. The development of the Lord Nelson class was a representative episode in the growth of electrification of British battleships. Late in the process, in May 1904, a conference was held on replacing hydraulic controls for heavy gun mountings with electrical control. Previously, electric motors had been successfully introduced as backup control gear with the Barfleur and installed on some other ships, as noted in Chapter 3. The general use of electrical motors as backup control gear had been further discussed in 1898, but Admiral A. K. Wilson, Controller at the time, declined to implement it. While the new panel was unanimous that hydraulic controls “left little to be desired in the way of improvements” those attending, who included the DNC, Engineer in Chief, the DNO, all their assistants and the naval assistant to the Controller, acknowledged that electric controls might have some advantages. One important item of concern was that gun recoil was absorbed hydraulically, which meant that hydraulic equipment could not be eliminated to save weight and space. To address this problem, it was suggested that

\[518\] Series of minutes between DNC, DNO and Controller, 1898, TNA:PRO ADM 256/34.
springs be used to absorb recoil. Vickers, makers of the guns and gun mountings for the ships, was directed to develop a system for one turret for trials.\footnote{Ship’s Cover, \textit{Lord Nelson} Class, No. 197, NMM.}

While springs were not a successful substitute for hydraulic recoil absorption, there are several important points here. First, even though hydraulics were highly regarded by the gathered technical experts, they were still willing to try electrical gear. Second, when they decided to introduce electrical gear for a new function (\textit{primary} gun training gear, as opposed to secondary) it was installed on a limited basis for a trial in an effort to accumulate practical experience to compare to the older systems. Finally, in order to overcome the fact that hydraulic gear in the gun mounting could not be eliminated, even if electrical gear was a successful replacement for gun training, the gathered officers were willing to try a radical solution in an attempt to find new ways to save weight and space. The officers of the Royal Navy showed themselves willing to experiment with new technology in order to attempt to improve their ships.

\textit{Conclusion}

The standard pattern battleship came under pressure at the turn of the century. The leadership of the Navy wished to upgrade the details of the pattern to meet the potential threats posed by improvements in foreign battleships. However, it was not possible to give the ships greater capabilities without breaking the size and cost constraints of the standard pattern, which the leadership of the Navy did not want to do. Trying to reconcile these mutually exclusive desires placed tremendous pressure on decision
making process, so much so that it threatened to paralyze the entire battleship development process. It did not. The Navy had a system that was robust enough to stand up to severe stress and continue to produce quality ships.

Ultimately, after extended discussion, the Navy refused to accept firepower, protection and speed below certain limits and was forced to increase the size of the planned *King Edward VII* class. However, the increase in size and expense was small and still severely constrained the ships systems. Interminable arguments about the relative importance of ships systems and minimum requirements broke out. Decisions which seemed final were revisited, both because ships systems were so integrated that they could not be considered in isolation and because some officers, especially Admiral Wilson, the Controller during the design of the *King Edward II* class, could not or would not allow decisions that went against them to remain final and insisted on revisiting them. William White, still DNC until January 1902, was no longer effective in providing leadership on design questions. The fiasco surrounding the design and construction of the Royal Yacht, *Victoria and Albert*, consumed much of his time, undermined his credibility and led to his absence on extended sick leave. This created a vacuum that no one filled and encouraged the lack of decisiveness.

On top of the problems of “fitting” the desired systems and their capabilities into ships severely constrained by size and expense limits, several important issues dealing with specific systems complicated the process. Cordite, the smokeless propellant introduced by the joint Ordnance Committee was unsatisfactory to the Navy. Sustained effort was required to convince the Army dominated Ordnance Committee that an
improved propellant was needed. The result was a modified form of cordite, cordite MD, that was a definite improvement, but still not wholly satisfactory to the Navy. Further pleas fell on deaf ears, however and the Navy was forced to make due, though in fairness cordite MD was a superior product that was about as good as it was possible to produce at the time. Still, the effort absorbed time and attention and was a source of frustration.

A more important issue was the prolonged and very messy fight over boilers. The Navy had adopted Belleville type water-tube boilers for the Canopus class of battleships and a number of cruiser classes. Reliability and maintenance problems, some of the severe, emerged as manufacturers and naval engineers adapted to the new technology. There were some very strident calls to return to the older tank boilers and, unusually, critics appeared in Parliament questioning a technical decision reached by the Navy. A Committee was formed to investigate. After a very extensive investigation, its opinion was generally in favor of water-tube boilers, but it declined to endorse the Belleville type and advocated a compromise mixed tank and water-tube boilers to attempt to gain the advantages of both. The Navy’s Engineer in Chief, Admiral A. J. Durston, who was partly responsible for the adoption of Belleville boilers, stridently rejected the Committee’s findings and accused it of bias and deliberate misinterpretation of the data. Such ferocity was rare in the closely-knit environment of the Navy and greeted with great distaste by the Board. Durston’s aggressive posture was the most extreme deviation from collegiality of the period and it highlights the acrimony that entered into interactions in the Navy on important decisions.
The *Lord Nelsons* were delayed by a similar breakdown in the ability of the Board to reach consensus, caused primarily by the necessity of jamming too much into too small and cheap a hull. Fortunately for the Navy, the acrimony associated with the *King Edward VII*s had died down somewhat. The Navy was also fortunate to have begun to accumulate more hard data on the effectiveness of its medium sized (six inch to 9.2 inch) guns and on the effectiveness of armor at stopping them. This information allowed for much more clarity in defining what configuration was “best.” While overshadowed by the *Dreadnought* and its successors, the Lord Nelsons were easily the best of the pre-dreadnought battleships.
Conclusion

The Royal Navy went through an important period of growth and development between 1889, with the passage of the Naval Defense Act, and 1905, when construction on the *Dreadnought* commenced. It built eight different battleship classes, each containing improvements over previous designs, for a total of 42 new first-class battleships commissioned, with five more under construction. Five other second-class battleships, smaller ships designed for specialized purposes that did not require the power and expense of a first-class ship, were also built or bought. All were, at the very least, as good as any in the world, and most were likely better. This growth and development, often overshadowed by the Fisher/*Dreadnought* era that followed, was an important period for the Royal Navy. Though the pre-*Dreadnought* era of ship design and construction is often seen as a period characterized by resistance to change and self-satisfied indifference to the value of new technology for naval warfare, it was instead a period of cautious, measured, and successful adaptation of new technology, which produced powerful and effective battleships.

The Royal Navy was able to do this because it had developed a systemic method for designing ships and incorporating new technology into those designs. The system was able to decide effectively on the role the battleship would fill within the broader context of naval operations. It decided how to balance the competing demands of the
capabilities desired to fill that role, within an environment of strict limits on space, weight, and money available. The system also evaluated new technology, and determined what filled the Navy’s needs and would produce better ships.

This system had several primary characteristics that contributed to its success. First, it was collective and collegial. Second, it was composed almost exclusively of naval officers. Those two factors together meant that the system harvested the collective experience and wisdom of a long serving, highly professional officer corps, and made that knowledge readily available in the decision making process. Third, it was not dependent on any individual to work. Officers might come and go from posts of authority, but the process was institutionalized at both a formal and informal level and was not dependent on the ability of any one man. The process did, however, allow exceptional individuals to influence the system, in both positive and negative ways. The most important individual was William White, DNC, who was also the only civilian not a First Lord to have real power in the process. White was widely regarded as the most technically capable ship designer in the world, and the number and quality of the ships he designed for the Royal Navy (and other navies in his brief period in the private sector) tend to support such an assessment. He was also articulate and able to lead the naval officers who otherwise regarded ship design as within their exclusive professional competence.

Fourth, the process drew heavily on empirical information from trials and testing. The leadership of the Royal Navy wanted hard data, and accepted tests’ and trials’ definitive answers to questions of effectiveness, in both relative and absolute terms.
Finally, the system was sufficiently robust that it was able to continue to function under stress. In the early 1900s White was lost to the process. Improvements in the battleships of other navies made it increasingly difficult to “fit” the desired capabilities into the self-imposed limits on ship size and cost. Discussion, slow before, became interminable, and the collegial atmosphere sometimes broke down. The system bent, but did not break, and high-quality battleships were designed and built.

There were several second-order characteristics, equally important, that followed from those five. First, the system was cautious about adopting new technology. The collective nature of the process meant that more than just a few individuals needed to be convinced that something new would be a positive. In addition, the naval officers who dominated the system were by temperament and training conservative, and not inclined to take risks. These men were not against new technology _per se_. After all, they worked with equipment that was, for the time, among the most sophisticated and technologically advanced in the world. Their education was almost exclusively technical and they had respect for the uses of technology. They also knew its limits, and the value of reliability and predictability under difficult conditions. Sometimes this meant technology that was clearly useful in hindsight was not adopted as soon as it might have been, but it also meant that risks to reliability were minimized and limited resources were not wasted pursuing dead ends.

Also, the process was slow. There was little sense of urgency within the Admiralty and very little administrative support for its leadership. Mundane administrative tasks consumed much time and effort, and diverted attention from key
issues. The nature of long-term service within a relatively small officer corps meant that the leadership of the Navy placed a higher value on maintaining good working relationships. The collective nature of naval decision-making emphasized the importance of this practice, and accorded senior officers the respect that inclusion in the process brought. The Navy valued these and the cohesion of the officer corps more than speed in the decision-making process. The large number of people involved also slowed the process down, as it took time to consult individuals, particularly those not at the Admiralty offices in London. Running tests and trials also took time, sometimes substantial time, and waiting for those reports could represent a substantial delay.

The caution and lack of urgency was reinforced by the military and geo-political conditions that the Royal Navy operated in. The Navy simply did not need to innovate to achieve its goals; it had already met them. Great Britain and its Empire were secure. The Navy could not remain static—that was obvious to its leadership—as the military and technological environment was changing much too rapidly for that. The Navy needed to grow, and it needed to respect the way that new technology would change military conditions. The Royal Navy needed to investigate and adopt new technology to continue to fulfill its mission. The leadership of the Navy could not be complacent but it did not need to take significant risks; it did not need to pursue a “high risk, high reward” strategy.

This last point is often overlooked. Partly, this has to do with hindsight. We, as future observers, know what is coming and can see with some (though not complete) clarity what paths the Royal Navy needed to take to take full advantage of the technological changes of the time. In addition, historians focus on the
Fisher/Dreadnought era, which followed this time period. Technological change had further accelerated, and the development of the German Navy required a more expeditious process of ship design and technological adaptation for the Royal Navy to retain its superiority. A final part of this is that Fisher, and others who were dissatisfied with the rate of change before Fisher became First Sea Lord in 1904, were successful in creating the impression that the leadership of the Royal Navy was not just cautious, but reactionary. If the leadership of the Royal Navy was technophobic, there is no reason for historians to consider other reasons why it might not have moved to experiment more aggressively with new technology (or even if it was grappling with issues of new technology at all). Complementing that point, while most of the ships discussed here did serve during World War I and the Lord Nelsons in particular were quite successful, collectively these ships were much inferior to the Dreadnoughts built later. This reinforces the impression that the Royal Navy was backward before the Dreadnought—and compared to what came later, it was. However, that does not mean that these ships were not powerful ships at the time they were built.

This leads to the final point. The period between the Naval Defense Act in 1889 and the Dreadnought in 1905 is a vastly underappreciated period in the history of the Royal Navy. It was not a period of failure for the Royal Navy, as least so far as ship design and technological advancement were concerned, that can be dismissed as

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520 All but one of the Royal Sovereigns had been broken up prior to the War, and the Hood was sunk as part of the harbor defenses at Portsmouth. In addition, the Montagu, a Duncan class ship, was lost to an accident in 1906. The second-class ships constructed for the Navy, the Centurion class and the Renown, had also been broken up well before the war. All other battleships discussed in this study served in World War I.
something that “Jackie” Fisher needed to fix. The Royal Navy had its failures at that
time, to be sure. However, it did not fail to design its ships effectively, to grapple with
new technology, and to adapt and adopt it for its ships, most importantly, its battleships.

This study has begun a deeper investigation of the Royal Navy before “Jackie”
Fisher and the *Dreadnought*. It has demonstrated that the Royal Navy had an effective,
institutionalized system to decide what capabilities its ships needed and how to balance
the competing demands within strict limits. Further, the leadership of the Royal Navy
was concerned with technological change, and interested in using new technology to
improve its ships. Finally, it has demonstrated that the Royal Navy was successful in
building a large number of high-quality, technologically advanced battleships before
“Jackie” Fisher and the *Dreadnought*. 
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