DEVLOPMENT OF THE WORLD'S FASTEST BATTLESHIPS

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Introduction

The IOWA Class battleship represented the zenith in classic warship development on the eve of the Second World War. Their design was born of an era filled with political and budgetary constraints, where liberals and conservatives argued about the reality of overseas threats and how to react to them. In 1936, the newly formulated London Naval Treaty forbade the construction of battleships in excess of 35,000 tons displacement. Believing its own intelligence sources regarding Japanese construction, the U.S. Navy went ahead with the design of a 45,000 ton "super battleship" which would be the fastest the world had ever seen. A year after the London Treaty was ratified; its restrictions were lifted to accommodate construction of the IOWA Class battleships. The IOWAs were the fastest and most survivable surface ships when they appeared in 1943-44, and they saw service in three additional conflicts, up through 1991. How did these battleships stand the test of time so well? The answer lies in the superior engineering, foresight, and political intrigue associated with their development.

The Washington Naval Treaty

It is difficult to separate engineering from politics in unraveling the evolution of the IOWA Class. The road leading up to capital ship design in the late 1930's is one that follows a very delicate and tangled path. Although some events may initially seem distant in their relation, as an aggregate total, their summation provides insight into the military, engineering, political, and budgetary process that remain in place today.

In the period during and following the First World War, the path leading up to construction of a capital warship became increasingly complicated and mired in constraints developed within the prevailing attitudes governing military appropriations. During the First World War (1914-1918), naval architects within the design section of the U.S. Bureau of Construction and Repair busied themselves with continuous design modifications, brought on by wartime experience. The great European conflict droned on with almost casual American naval observance until the Battle of Jutland in 1916. Jutland's outcome substantially modified and controlled naval engagement theory for the next 25 years.

One of the prominent results of Jutland was the evolution of extensive armor protection needed for large-gun battleships if they were to serve as the capital sea-control ships of the future (1). Speed was seen as a consideration secondary to staying power required for continuous operations away from home waters (such as the British Blockade of the German squadron). Large gun battle cruisers evolved as a tool capable of high speed response, should a sudden threat require dash speed capability (much as cavalry was used in ground warfare at the time).

Another outcome of Jutland was that most contemporary observers deduced that a large, well-armed battle fleet could hold potential enemies at bay regardless of a vessel's particular individual qualities. Tactically, the Germans had fared well considering their lack of numbers and inferior tactical position (2). Their ships incurred much less damage due to their superior design in the area of munitions storage and protection. However, the British had drawn the *strategic victory* in tying the German High Fleet to their ports.

At this juncture, the simple lesson in superior *numbers* became apparent to everyone and appropriations for capital warships soared. America was no exception. In August 1916, the U.S. Congress passed an ambitious naval construction program which mandated the unprecedented construction of sixteen battleships and battle cruisers, more than doubling the available firepower of the entire Navy. The "order" overwhelmed the Bureau of Construction and Repair at a period when design evolution was occurring at a rapid pace.

In November, 1918, World War I ended with most of the American capital ships still under construction or in authorized design. Congress followed the war with the Naval Act of 1919, which basically continued the flow of funds necessary to complete the ambitious World War building program. The Naval Act of 1919 had purely political motives. Congress did not feel it necessary to continue construction, but did so in order to leverage Great Britain into joining the newly-formed League of Nations, which President Wilson endorsed. At that time, the American ship building program was superior to the British in displacement and main gun caliber because they were designed later, with the wartime experience and technological advances not available to the British, whose battleships had been constructed during the war.

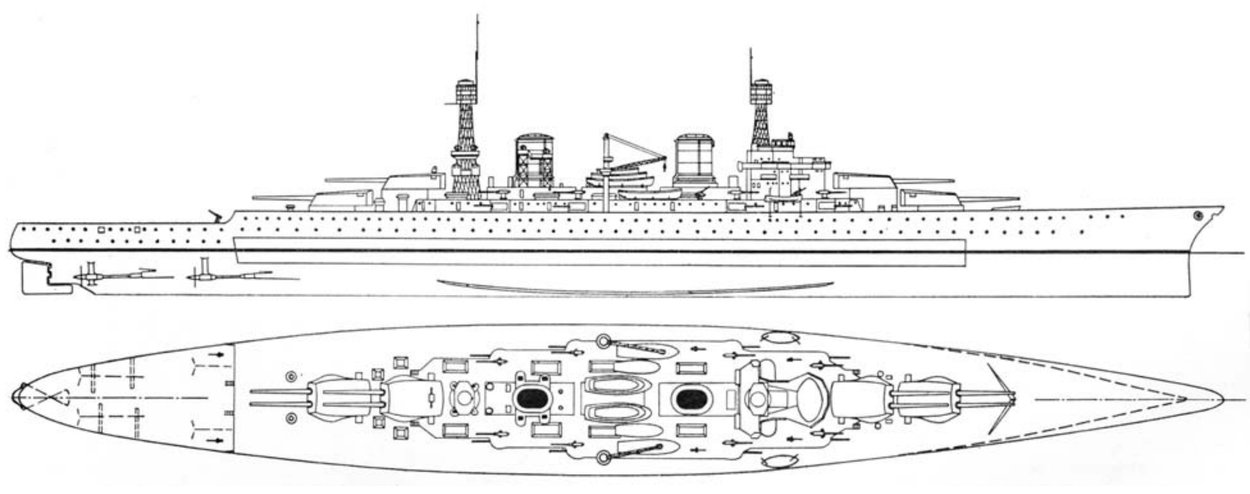

Figure 1 - Final design layout for the six battle cruisers of the LEXINGTON Class which began building in 1920-21. The original design called for seven funnels. This was the first capital ship class to incorporate the bulbous bow, a discovery made during model towing tests by RADM D.W. Taylor at the Washington Navy Yard. The bulbous bow reduced drag by 6% at speeds in excess of 25 knots. (taken from Breyer, 1970).

In 1921, a change of American administration was ushered in with Warren Harding. That same year a Naval Appropriations Bill was passed which was intended to serve notice that the United States would strive to be a naval power on parity with Great Britain, or even greater, as their capital ships would be newer and with larger caliber armament. The 1921 Naval Appropriations

Act continued funding for construction of sixteen 16-inch gun battleships and battle cruisers (Figure 1). The disarmament tendencies of the Wilson Administration and the British Labour Party were dealt a great blow. This position of undisputed naval supremacy allowed the United States to become the undisputed power broker for a strategic arms limitation treaty. The other signatories came to the table in an effort to stem the ambitious building plans of the Americans. In this respect the Act provided exactly the impetus that it was intended to.

On July 11, 1921, President Harding called for a naval conference of the major naval powers: Great Britain, United States, Japan, Italy, and France. In Britain, Parliamentary forces were searching for financial relief by suspending new naval construction. They achieved this by agreeing to numerical parity with the United States, albeit with somewhat older and smaller caliber units (3). The American Secretary of State convened the major naval powers in Washington D.C. on November 12, 1921 to draw up what became known as the Washington Naval Treaty. Their aggregate goal was to limit the size and number of capital warships. Never before had politics played so important a role in warship design. But, massive industrial and technological advances had been made during the First World War (1914-1918) that were giving rise to a naval arms race in the shadow of a great conflict which had bankrupt the principal naval power at the time, Great Britain. At the same time, the modern battleships then being designed and built had become large capital expenditures worthy of considerable governmental scrutiny during a period which witnessed the initiation of individual income taxation and national indebtedness.

Figure 2 - RADM David W. Taylor (far left), Chief of the Bureau of Construction and Repair, and RADM John K. Robison (far right), Chief of the Bureau of Engineering, hold a model of the LEXINGTON Class battle cruisers under construction in March 1922. In the foreground is a model of an aircraft carrier design converted from the battle cruiser hull, a transformation that was realized for two of the hulls after ratification of the 1922 Washington Naval Treaty. Naval Historical Center photo.

The treaty was concluded on February 6, 1922 and the last signatory ratified on August 17, 1923. Unlike any previous international agreements, the Washington Treaty specifically limited individual and aggregate displacement of capital warships. Battleships were limited to 25,000 tons, carriers to 27,000 tons, and converted carriers to 33,000 tons. These "treaty displacements" included all normal displacement items with the important exceptions of fuel oil and reserve feed water. In addition, an obscure clause (4) was included to provide for an extra 3000 tons as a "means" for providing additional protection from air and sea attack (5). This clause likely emanated from General Billy Mitchell's successful aerial bombing demonstrations a short while before (Melhorn, 1974). The United States and Japan opted to convert several of their largest battle cruisers into aircraft carriers (Figures 2 and 3), which would form the nucleus of their embryonic carrier strike forces between the wars, having superior speed to any other capital ships.

The Treaty Years (1926-36)

In the ten years preceding the expiration of the Washington Treaty (1926-36), conservative factions of the Allied naval powers realized that the Axis nations were advancing pell-mell with ambitious construction programs. Japan had withdrawn from the accord at the end of 1934 (as she was entitled to do) and promptly embraced a "cloud of secrecy" regarding her naval construction which elicited more than a little paranoia amongst British and American observers.

Figure 3 (top) - Bow view of the U.S.S. LEXINGTON (CV-2) at anchor in San Francisco Bay in 1934. The slender sheer of a sleek cruiser hull shows to good effect. The LEXINGTON Class hulls were 26% to 30% complete when original construction was halted in late 1922. This demarcation can be seen as a paint tone change on the hull (photo author's collection).

Figure 3 (bottom) - Stern view of the U.S.S. SARATOGA (CV-3) in 1934. The 2-1/2 foot amidships blister and tapered shear of the stern transom are obvious. Note the wide spacing between screws necessitated by the tapered stern section. The single rudder and high slenderness ratio enabled a fast ship, but with poor turning characteristics, which proved troublesome during the Second World War (photo author's collection).

As a signatory to the Washington Accord, Japan had been required to report all of the details of her naval construction (size, armament, protection, and propulsion details). The Japanese penchant for secrecy soon gave rise to rumors of 16-inch guns, super battleships, and the construction of the "Gibraltar of the Pacific" at Truk Atoll. In January 1938, the British Ambassador to Japan made an official inquiry as to whether Japan was building battleships of greater than 35,000 tons. The Japanese declined, as a matter of principle, to provide any information as they were no longer required to do so (having withdrawn from the treaty). After much diplomatic prodding, in December 1938, the Navy Minister, M. Yonei, declared that the Japanese "had not laid down any ships of 40,000 or 45,000 tons" as had been asserted by western intelligence sources. This diplomatic declaration contained some truth - the super battleships under construction had displacements in excess of 60,000 tons!

The Quest for Speed

By 1935, empirical formulae had been developed which could successfully predict maximum capable speed by utilizing the *length-to-speed ratio* developed for 12 m competitive yachts, was given by: speed $= \sqrt{1.408}$ (waterline length). In those days, design speed estimates were based on model studies in flumes of various hull forms, tests on large model propellers, and tests with a self-propelled model (Taylor, 1911; King, 1971; Carlisle, 1998).

The scaling up of model performance, however, is not straight forward. There exist large differences in the character of flow because the viscosity of water and gravitational field cannot be scaled down in model ship basin tests. The models had to be large enough to generate turbulent flow about the hull in order that drag could be evaluated. For capital ships, this usually meant that model hulls greater than 20-feet long were needed to generate Reynold's Coefficients in excess of 2000, which is the boundary between laminar and turbulent flow.

Early on in the pursuit of speed, it became apparent that propeller cavitation (7) was the single-most important consideration at speeds in excess of 30 knots. Propeller design, therefore, took on new meaning and importance if speed was going to be sought after. When cavitation occurs, the propeller efficiency falls off drastically and propeller damage could result. Model tests proved ineffective in the prediction of high speed propeller cavitation (Raven, Feiler, and Jesperson, 1947). Attention then had to be focused upon prototype testing of actual propellers, usually on destroyers (the 1500-ton destroyer MAURY [DD-401] achieved a speed of 42.8 knots using 52,000 shp during her builder's trials off San Francisco in 1938).

Hull shapes had evolved considerably during the interwar period for reasons of survivability and extending their operational radius. Hull blisters were added to combat torpedoes and triple bottoms were placed as added protection against mines. With further conversion over to oil-fired boilers, much additional fuel could be carried in the protective blisters and outer hull compartments. In the British Queen Elizabeth Class, blister additions of up to 13.1 feet lessened the length-to-beam ratio from 7.13 to 6.29, reducing their speed by 1 to 2 knots. In the realm of capital ships, only the English HMS RENOWN could reach and sustain 29 knots - this being because of a complete refit in 1936-39 in which she converted to fuel oil-fired boilers whose space savings enabled a 40% increase in fuel storage capacity. In order to maintain their speed, hull shapes had to evolve in order to compensate for the greater beam. However, the battleships were slow, and operated with hydrodynamic principles associated with speeds of less than 25 knots.

Sustained speed experiments were conducted on capital ships by the Navy in 1933-34. In 1933, the USS SARATOGA (CV-3) had successfully transited from San Pedro, California to Pearl Harbor, Hawaii at an average speed of 33.4 knots by sustained development of 212,000 of her designed 180,000 shaft horsepower (shp). A maximum speed of 35.6 knots was attained and sustained for over 16 hours at one point (although these values are still world records, the SARATOGA exceeded these on her emergency run from San Diego to Pearl Harbor on 7-10 December 1941 when she sustained 218,000 shp)

Up until that time**,** the SARATOGA's high speed feat was unprecedented. Because of her voluminous fuel storage capacity, she could outrun destroyers on short bursts, but also enjoyed a 4-fold endurance advantage. Some in the Navy were excited at the prospect of developing a battleship with battle cruiser speed and endurance. The capabilities of the LEXINGTON and SARATOGA proved the concept was possible. Tests on model hulls greater than 20 feet long at the David Taylor Ship Model Basin suggested that the *length to speed* ratio for large battle cruiser hulls reduced to something close to: Capital ship speed = 1.19 √length at waterline

The London Naval Treaty of 1936

As the clock ran out on the Washington Naval Treaty, liberal factions in the United States and Great Britain moved to replace it with a new agreement. Conservatives dissented, pointing out the ambitious building programs of Japan, Germany, and Italy which were turning out warships of the latest and most modern design. The liberal factions won out for the time being, leading to the Naval Treaty of London which was ratified on 26 March 1936 (signed only by Britain, France, and the United States). The Washington Treaty "maximums" of 35,000 tons and 16-inch main caliber were retained, as before. The only additional limitation was that aimed at the German's pocket battleships by limiting cruisers to 8000 tons and 10-inch main caliber (the Deutschland Class pocket battleships then under construction carried 11-inch rifles). The London Naval Treaty came into force on 1 January 1937 and was intended to run until 31 December 1942.

The treaty ratification came as a significant "setback" for political conservatives pointing to what they felt was a rapidly eroding numerical advantage enjoyed by the Anglo alliance. When taken together, the Axis threat could engage either Great Britain or the United States on fairly equal terms. From 1934 onwards, U.S. naval planners went ahead with designs for “super battleships” of 45,000 tons in response to the Japanese pull-out from the Washington accord. The London Naval Treaty, therefore, had been a great setback in light of the intelligence information being gathered at the time (6). Construction of the colossal YAMOTO Class battleships was known within the higher echelons of the Navy Department, but could not be made public.

The Second Vinson Act (1938)

The Naval Act of 1936 had authorized the construction of the first American battleships in 17 years, though the London Naval Treaty still limited battleships to 35,000 tons and 14-inch guns. There was an exception clause that allowed larger construction if a signatory cancelled or broke the treaty, which Japan did in 1937, just as construction got underway on the NORTH CAROLINA and WASHINGTON (Figure 4 upper). This allowed their main armament to be increased from twelve 14-inch to nine 16-inch rifles, but retaining defensive armor for incoming 14 inch shells (her original design).

Within 16 months of the ratification of the new London Naval Treaty intelligence reported that the Axis powers were rapidly constructing capital ships in excess of treaty limitations. This news suggesting that the Americans, British and French had locked themselves into a position of inferiority, with a widening gap developing. Conservative sentiment within the U.S. Legislature was that another war was imminent, regardless of the London Treaty, which, after all, had only been signed by three western powers patently resistive to another conflict. By May of 1938, Republican Congressman Carl Vinson, sponsored what has become known as the second Vinson Act, a new fleet construction law which mandated a 20% increase in the strength of the U.S. Navy.

The new Vinson Act provisions ignored the limitations of the London Treaty. On June 30, 1938, the Anglo signatories drew up a supplemental agreement which referred to a "sliding scale" clause in the 1936 agreement which allowed an increase in the standard displacement of capital ships to 45,000 tons. The reason for the supplementary agreement was Japan's rather antagonistic response to the well-intentioned inquires so recently made by the British. Such a negative response could only be taken to be an admission of guilt: the Japanese were up to something and it had to be large. Mr. Yonei's belated response (which came 11 months after the inquiry) came too late to forestall western suspicion, and therein confirmed the appropriate adjustment of the recently ratified London Naval Accords. As a consequence, the Second Vinson Act authorized an empty tonnage ceiling of 45,000 tons. Six new ships were ordered, the four units of the SOUTH DAKOTA Class (Figure 4 bottom) and the first two units of the IOWA Class, Iowa and New Jersey.

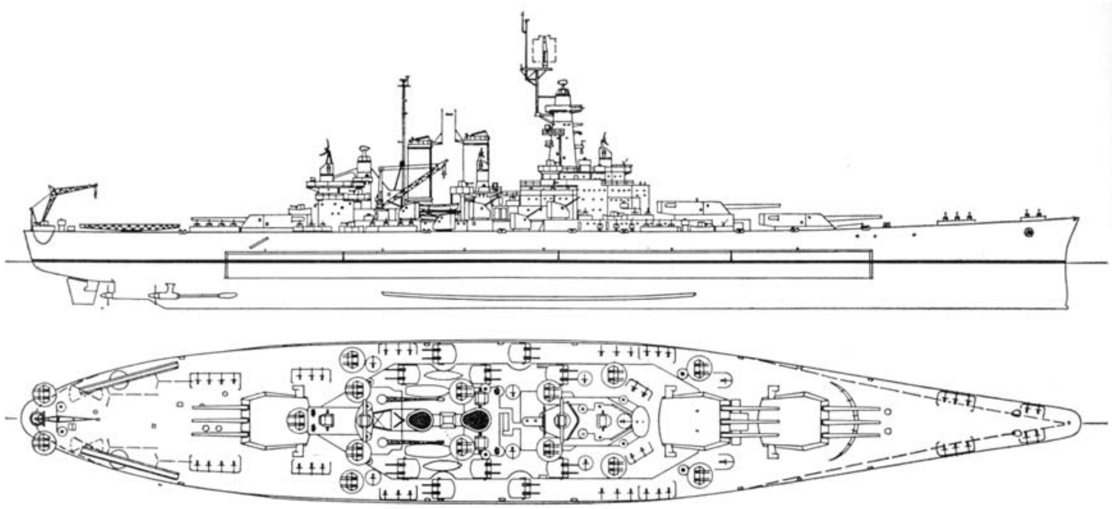

Figure 4 (top) - Line drawings of the U.S.S. WASHINGTON (BB-56), as configured in 1944. She was the second unit of the NORTH CAROLINA Class, the first of the post-treaty battleships. Her armor was only designed for incoming 14-inch projectiles, because the London Naval Treaty limitations. Note the wide transom and compact layout, novel measures taken to compress the vitals areas and thereby lesson armor tonnage. Taken from Breyer (1970).

Emergence of the IOWA Class

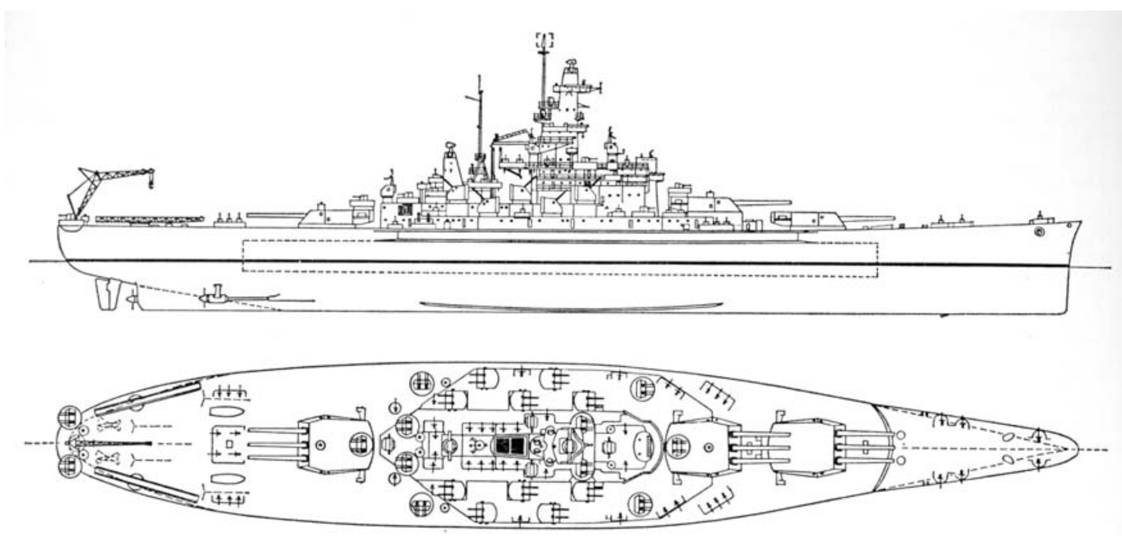

Figure 4 (bottom) - Line drawings of the U.S.S. ALABAMA (BB-58), second unit of the SOUTH DAKOTA Class. This class represents the zenith in compact design with maximum fire power, but with a top speed of only 28 knots, she could not keep company with the fast carrier task groups. Taken from Breyer (1970).

The sudden amendments to the London Naval Treaty in 1938 allowed for the construction of battleships of up to 45.000 tons displacement (unloaded). Plans for fast battleships of this size had been under development by the Navy Department between 1935-37. In fact, the IOWA and NEW JERSEY had been ordered on 1 July 1935 in anticipation of the amendments that would follow the cessation of the Washington Naval Treaty. On 12 July 1940, four more units of the IOWA Class, MISSOURI, WISCONSIN, ILLINOIS, and KENTUCKY were also ordered, thus completing the class.

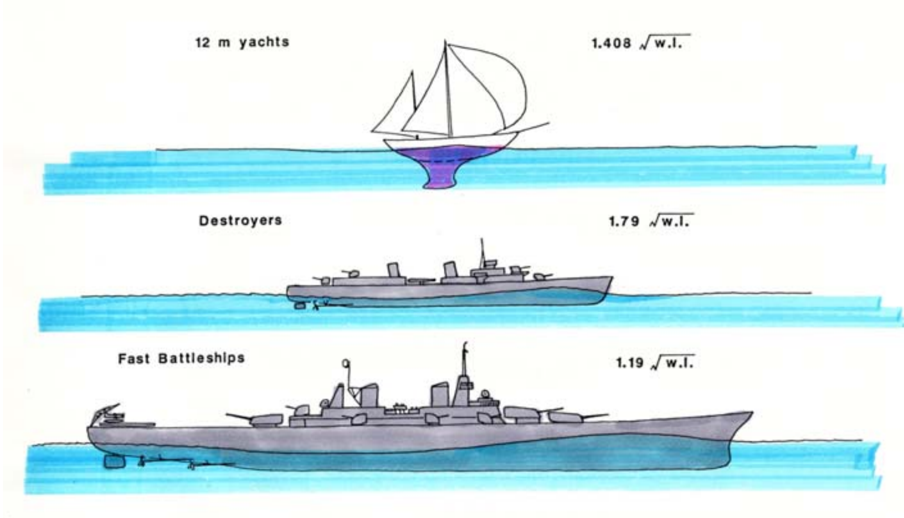

Figure 5 - Ssketch depicting the equations used to determine the optimal waterline length for maximum speed, for12 meter racing yachts (America Cup races), World War II era destroyers, and cruisers/fast battleships. These values were empirically derived from model hull studies at the David Taylor Ship Basin in Cabin John, MD in the 1930s and 40s. The length-to-beam ratio selected for the IOWA Class battleships was 7.96.

Figure 6 (left) - The width of the IOWA Class battleships was limited by the dimensions of the Panama Canal locks, which were 110 feet wide. TheIOWAs employed a beam of 108-1/6 feet. This beam dimension was then multiplied by 7.96 to determine the waterline length of 860 feet. This shows the IOWA transiting the Pedro Miguel Locks on June 6, 1984.
Figure 6 (right) shows the bulbous bow of the MISSOURI in drydock. Admiral David W. Taylor (1911) developed the bulbous bow conceptthrough a complex series of hull form tests carried out in 1910-11 at the Washington Navy Yard (both images from US Navy).

The increased tonnage limits were quickly combined with beam limitations of the Panama Canal locks (110 feet) to design the fastest class of battleships ever contemplated. The IOWA Class was designed according to the speed being equal to 1.19 x the square root of the waterline length (Figure 5). Their beam limitation would be *108-1/6* feet, allowing less than 2 feet of clearance through the locks of the Panama Canal (Figure 6 left). Before the Second World War, passage through the Canal was an absolute necessity for America to maintain a two-ocean navy. Planners recognized that the larger navy yards were on the Atlantic Coast while the principal maritime threat lay in the Pacific Basin.

A second theorem, arrived upon empirically, related waterline length to maximum beam. This ratio was seen to be *7.96* for a battleship and *8.85* for a cruiser. The battleship's heavy armor and large draft reduced the ratio from what it would be for something sleek like a yacht or cruiser (the LEXINGTON/SARATOGA had been designed at *8.85* and their turning characteristics were poor).

The IOWA Class would achieve these higher speeds by lengthening the forecastle and amidships. Hull model tests proceeded with great success at the Navy's David W. Taylor Ship Model Basin near the Washington Navy Yard (King, 1971; Carlisle, 1998). A large, heavily armored object could cut through seas in an exemplary manner while maintaining high speeds (Taylor, 1912). The IOWAs were the first capital ships fitted with bulbous bows, as shown in Figure 6 right.

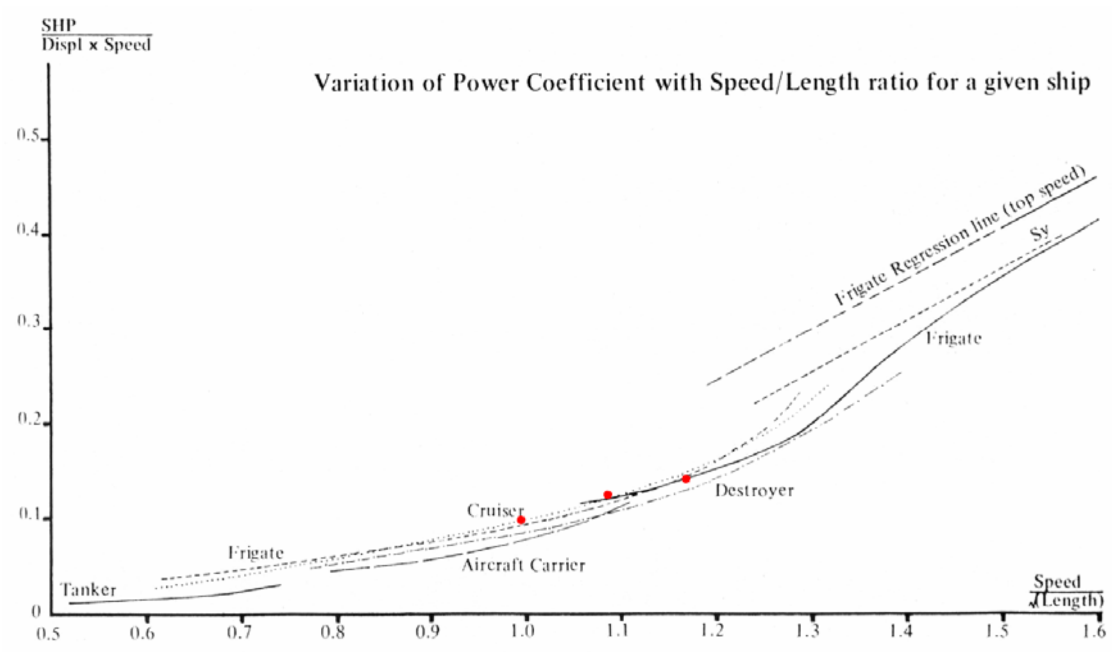

Figure 7 – During the 1940s naval architects established a hydrodynamic order or merit that eliminated the effect of displacement. The most common comparison was this graph comparing the "power coefficient" (shaft horsepower divided by the displacement and multiplied by the speed) against the speed divided by the square root of length ratio. The three dots are data points derived from speed trials for the IOWA Class battleships at various speeds and displacements. These plot very close to the line shown for cruisers. Chart taken from Brown (1977), with data added by the author.

With all of these numbers in mind, the IOWA's design reduced to the ships we basically see today, with a maximum beam = 108-*1/6* feet; waterline length = *860* feet; and theoretical speed = 34.9 knots (Figure 7). Such speed was simply unheard of a few years earlier. The older American battleships were capable of only 20 knots, while the newest classes of battleships (NORTH CAROLINA and SOUTH DAKOTA Classes) had flank speeds of 28 knots.

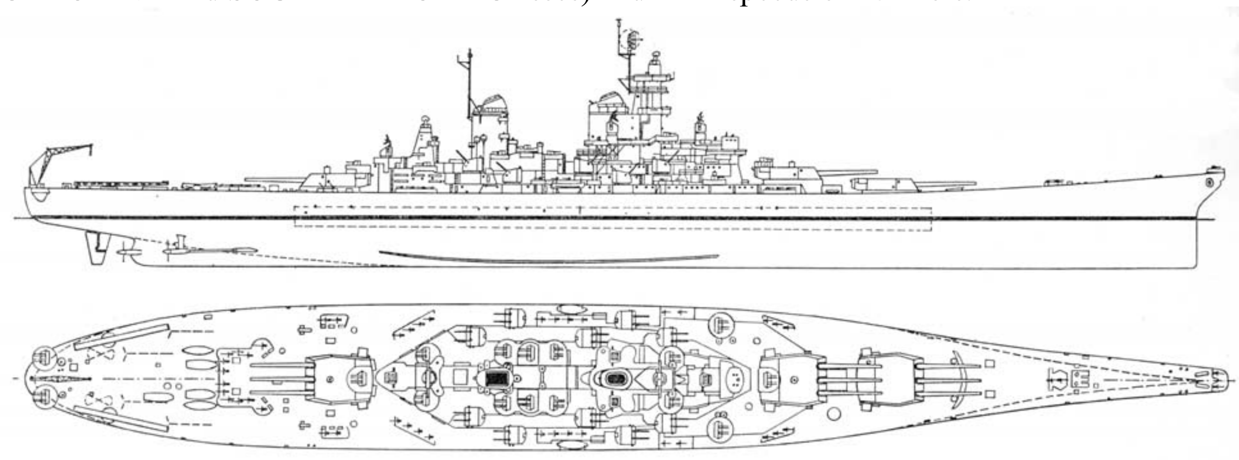

Figure 8 – Line drawings of the IOWA Class showing their radical departure from previous units in the employment of a much longer hull to achieve high speed. This was the fastest capital ship hull form that could be accommodated through the Panama Canal. Taken from Breyer (1970)

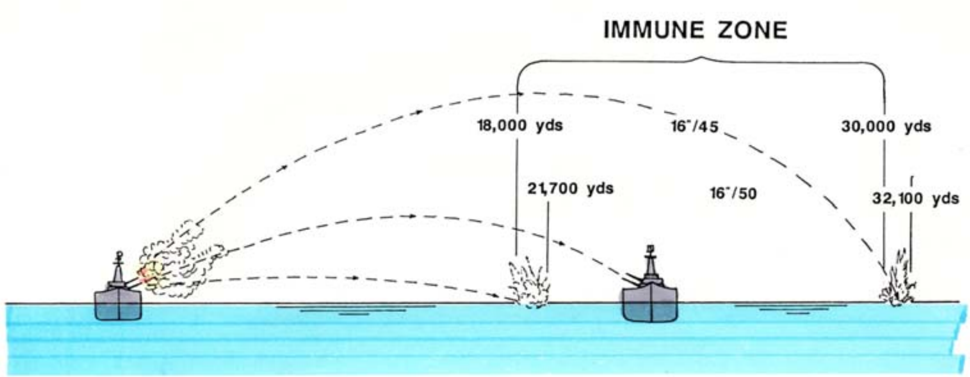

Figure 9 - The Iowa Class battleships were designed to be immune from 18-inch armor piercing naval gunfire at ranges between 18,000 and 30,000 yards. Below 18,000 yards the lower trajectories of incoming shells could conceivably pierce the inclined hull armor package.

The IOWA Class (Figure 8) would utilize 16-inch 50 caliber main battery rifles in triple turrets, similar to those employed in the NORTH CAROLINA and SOUTH DAKOTA classes (somewhat shorter 16-inch 45 caliber rifles). The IOWA Class utilized an ingenuous disbursement of side armor fitted perfectly flush with the ships' hull. Their side armor consisted of a wedge-shaped belt, tapering to a thin layer at the ship's bottom (this is what the Japanese designers used on the YAMATO Class during the same period). The horizontal armor reached a maximum thickness of 13.8 inches and yields no outward indication of bulges, blisters, or other protuberance hampering smooth hydrodynamic flow. This layout created an immune zone affording protection of the ship's vital components at ranges between 18,000 and 300, 000 yards, as sketched in Figure 9.

Figure 10 – Propulsion and steerage for the IOWA Class battleships included five-bladed inboard screws, 17 feet in diameter, with 4 bladed wing screws 18’-3” in diameter. The design power output was 212,000 shp, with a 20% overload (up to 254,000 shp). During the NEW JERSEY’s sea trials in December 1943 the engine room generated 221,000 shp, clocking 31.9 kts with a displacement of 56,928 tons. The IOWA’s design speed was about 33.5 kts (38 mph), but a lightly loaded hull (51,000 tons) would have been capable of achieving 35.4 kts (40.25 mph). US Navy photo.

The last component in effecting the efficient fast battleship was propulsion (Figure 10). In the late 1930's, the 50,000 shaft horsepower (s.h.p.) boiler represented the zenith in accomplishable technology. 600 psi Babcock and Wilcox boilers were mated with General Electric and Westinghouse (8) steam turbines of 50,000 designed shaft horsepower to provide a cumulative 200,000 shaft horsepower plant to drive 57,000 tons (loaded) of ship with a 38 foot draft. During builder's trials, 212,000 s.h.p was developed on all four units of the class driving them all to speeds in excess of 33 knots (the design requirement).

Empty displacement was distributed as follows:

Hull	13,500 tons	28.9%
Armor	18,700 tons	41.6%
Armament	10,800 tons	24.0%
Engines	2,500 tons	5.5%

Total empty displacement 45,000 tons

Despite their innovative design and the fabrication problems associated with such large amounts and varying thicknesses of steel, the IOWA Class hulls were built in record time. The IOWA and NEW JERSEY were completed in just 32 months, the WISCONSIN in 36 months, and the MISSOURI in 41 months; phenomenal rates by today's standards.

When the four IOWA Class battleships were re-commissioned between 1982-87, they retained their old 600 psi boilers while switching from Navy Special Fuel Oil to Distillate Fuel. Despite this, their range, speed, and ability to transit the Panama Canal made them survivable and flexible platforms. Like aircraft carriers, their armament was upgraded by deleting the secondary AA battery and accommodating 32 Tomahawk and 16 Harpoon missiles. The IOWAs were provided with Pioneer or Mastiff Remotely Piloted Vehicles (RPV's) operable off their spacious fantail area, and for awhile (1987-89), the Navy as contemplating Lighter-Than-Air (LTA) blimps accommodating the sophisticated array of electronic sensors (AWACS) and passive defensive capability (flares, chaff, radar reflectors).

Reductions in budgets and the high-manning requirements of the battleships saw the four IOWA Class ships decommissioned in 1990-92, beginning with IOWA in October 1990. Her sisters were retired soon after the first Persian Gulf War, the NEW JERSEY in February 1991, and WISCONSIN in September 1991. The MISSOURI was retained with a reduced crew to attend the 50^{th} anniversary of the Pearl Harbor attack in December 1991, before being taken off the active roll in March 1992.

The Illinois and Kentucky

The last two units of the IOWA Class were partially completed when World War II ended. The ILLINOIS (BB-65) was 22% complete at the Philadelphia Navy Yard, while the KENTUCKY (BB-66) was more than 50% completed at the building dock next door. Work on the ILLINOIS was suspended on August 15, 1945, and she was dismantled on the slipway. However, work on the KENTUCKY proceeded after VJ Day at a somewhat slower pace until February 17, 1947 when all activity was ceased. After being floated from the building dock, work recommenced 1-1/2 years later in August, 1948.

When work was suspended again in 1949, the ship was 70% complete. The KENTUCKY was placed in the reserve fleet at Philadelphia where numerous plans were subsequently formulated to rework her into a guided missile battleship (BBG-1). The last of these plans were rejected in 1958 and she was towed to Baltimore and scrapped from February, 1959 onwards. The KENTUCKY's bow section was removed in 1956 to repair the WISCONSIN, which had been in a serious collision with the destroyer EATON off the coast of Virginia. The KENTUCKY's four turbine sets were utilized in dual sets as the propulsion units for the first Fast Combat Support Ships, SACRAMENTO (AOE 1) and CAMDEN (AOE 2), laid down in 1961 and 1963 respectively. When the modern navy switched to 1200 psi boilers, black gang members from SACRAMENTO and CAMDEN proved valuable upon recall of the NEW JERSEY in 1968 and the rest of the IOWA sisters in the 1980's.

The Montana Class

On July 17, 1940 Congress passed the "Two Ocean Navy Construction Legislation" in anticipation of the imminent hostilities. In addition to the IOWA design, the Navy had been working on a 58,000 (empty) tonnage super-battleship concept since 1938. Five ships of this design, known as the MONTANA Class (Figure 11), were authorized as a follow-on to the IOWA Class. The super battleships were to accommodate four main 16-inch triple turrets with twenty 5"-54 caliber rifles in twin mount turrets as secondary armament (the first design usage of a 5"-54 caliber Mk 9).

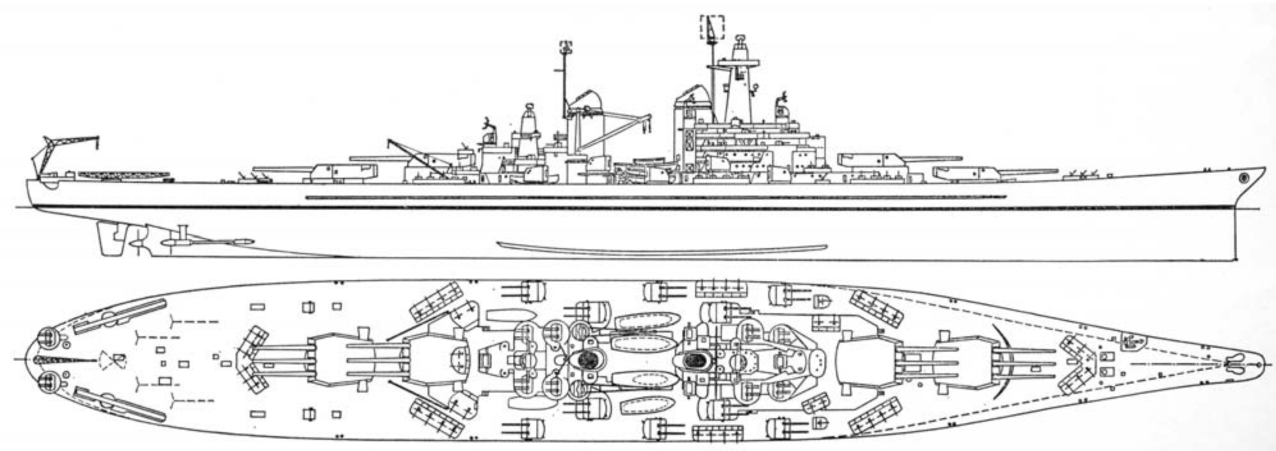

Figure 11 – Line drawings of how the MONTANA Class follow-on to the IOWA Class would have appeared. Much larger and heavier than the IOWAs, these ships would have shared the same power plant output of 200,000 s.h.p. As a consequence, their flank speed would have been only 28 knots. The dual rudders afforded to the IOWA Class were deleted in favor of a single centerline rudder, making theseunits less maneuverable. Taken from Breyer (1970).

With the advent of the Two Ocean Navy, came the realization that transit of the Panama Canal could no longer be a mandatory design constraint. The MONTANA Class would be big, with a waterline length of 890 feet and a width of 121 feet. This combination bore a length to width ratio of 7.35, far below the optimum sought in the IOWA Class. As the Navy's first departure from the Canal size limitations, the extra width was felt necessary in order to provide for a greater margin of safety against sinking (the battleships' susceptibility to capsizing was later proven by successful torpedo attacks in World War II).

Since it was still the late 1930's, the upper limit of efficient propulsion capability was still 50,000 s.h.p per turbine unit. As a consequence, the MONTANAs were designed to achieve 28 knots, similar to the NORTH CAROLINA and SOUTH DAKOTA Classes.

The MONTANAs were to be constructed in large building docks at Norfolk, Philadelphia, and New York, and only floated out when near completion. Even though ordered, the MONTANAs were not laid down because the major shipyard slips were crowded with Essex Class Carriers, ordered at the same time and prioritized higher after the Pearl Harbor attack.

After the Battle of Midway, the large gun battleship was relegated to the largely supportive role of providing anti-aircraft screen. In this role, the plethora of Antiaircraft (AA) batteries in the NORTH CAROLINA/SOUTH DAKOTA class made them highly desirable as defensive bulwarks in the Carrier Battle Groups. Their detraction was dash speed, still 5 knots slower than the carriers and their associated screens. The IOWAs were more than welcomed during their fleet introductions in 1943-45 because of their great speed and unequaled AA battery.

The MONTANA Class ships were cancelled on July 21, 1943, in favor of the MIDWAY Class aircraft carriers. Like the MONTANAs, the MIDWAY Class superseded the Panama Canal restraints and shared a hull form quite similar to the MONTANA Class (waterline length of 900 feet, beam of 121 feet). The first three units of this class were completed in 23 to 41 months each, between 1945-47.

Conclusions

Although propulsion technology has advanced far beyond that available in the late 1930's, overall hull design precepts have not changed dramatically. The length to speed ratios established in the 1930's still stand today. The modern navy operates with 1200 psi boilers (versus the IOWA's 600 psi machinery), but, the end result of 212,000 developed s.h.p. remains as significant today as it was in 1940. Today, 90,000 ton Nimitz Class carriers develop 260,000 s.h.p. via four steam turbines to drive their somewhat larger bulk at a 33 knot speed equivalent to the IOWA Class. They operate with a waterline length to width ratio of 7.78, which lies between the IOWA and the MIDWAY hull forms.

The IOWA Class battleship emerged from the drawing boards of depression-ridden America, based upon trial-and-error theorems seen in the practices and performances of that era. They were built and operated before the dawn of the Nuclear Age and without Space Age computer-aided design. In the interim of their demise, they were chastised as being unimaginative ghosts of a bygone naval era, incapable of periodic modernization like the air wing of an aircraft carrier.

When all is weighed and considered, the IOWA Class battleships represented the epitome of 20th Century warship design; well thought out and constructed as the fastest battleships ever built. They weathered time gracefully and were re-commissioned for a mere $350 million in the mid-1980s, the same cost as a PERRY Class frigate. NEW JERSEY was re-commissioned a record four times. Today, the Navy retains ownership of the NEW JERSEY (in Camden, NJ) and WISCONSIN (Norfolk, VA) in their inactive reserve fleet, should the need arise for ship-to-shore gunfire support. Both vessels are open to the public. The MISSOURI is now berthed on Ford Island’s famed Battleship Row quays at Pearl Harbor, not fare from the battleship ARIZONA Memorial. The City of Stockton, CA plans to display the WISCONSIN in a similar manner, as a tourist attraction, after San Francisco refused the vessel. The resilience of the IOWA Class battleships speaks to the indomitable foresight of America's naval architects in the mid-1930s, when capital ships were actually designed by naval officers, in concert with civilian contractors.

END NOTES

1. This was because the British had lost three lightly armored battle cruisers during the Jutland engagement in 1916.

2. The British had crossed the German's "T", thereby bringing all of their turreted main batteries to bear on the Germans, who could only fire forward.

3. Major British units of this period carried 14-inch and 15-inch caliber guns while the newly constructed American ships were sporting 16-inch main battery armament.

4. Washington Naval Treaty of 1922. Chapter II, Part 3, Section 1, Article (d).

5. This extra tonnage allowed for the successful conversion of the LEXINGTON and SARATOGA to aircraft carriers. See Freidman, 1976, p

6. Although our intelligence operatives painted a "dark picture" as to the rapid increase in Japanese building activities, they still managed to miss many major developments such as the rearmament of Japanese cruisers from 6-inch to 8-inch main batteries and the actual size of the four KONGO Class battleships.

7 Cavitation occurs when the pressure on the forward side of the propeller drops below the vapor pressure of water (-l atmosphere) and then "boils" or explodes, thereby effecting damage to this location.

8 During the depression years, government contracts were configured to disburse major mechanical procurements to all of the available suppliers. In this manner, major fabrication centers were kept open and competition maintained.

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