

Military Innovation and Carrier Aviation—

The Relevant History

By JAN M. VAN TOL

USS Lexington.

Major differences between the United States and Great Britain in both the development and employment of aircraft carriers and carrier aviation in the interwar years suggest how innovation was highly successful in the American case and much less so in the British. The only country with carriers at the end of World War I was Britain. It had used carrier-based aircraft to carry out the sort of missions that characterized mature operations during World War II. Royal Navy leaders supported aviation in the fleet. Yet by 1939 Britain was outclassed by America and Japan because of its obsolete carrier aircraft. How was such a reversal possible?

The early 1920s found the United States with huge capital ship construction underway and approaching Britain in Mahanian splendor. A decade later, the battleship remained dominant while the battle force was far smaller than anticipated. Two carriers entered service and promised to alter naval warfare, and six months after America entered World War II carriers decisively changed the nature of the Pacific War. The most important development leading to this capability took place in an era of disarmament and severe budgetary constraints.

Revolutions in military affairs are driven by the interplay of technological, operational, and organizational factors. This article describes the historical evolution of British and American carrier aviation, with emphasis on those factors. An article in the next issue of *JFQ* will analyze how this revolution succeeded in America, why it was less successful in Britain, and the subject of military innovation in general.

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U.S. Navy

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Early Developments

Improvements in battleship gunnery allowing accurate shooting beyond the horizon spurred naval aviation. The period 1900–14 was one of intellectual ferment. Leaders such as Mahan and Luce fostered intellectual curiosity and experimentation. It was the era when steam turbines, long-range guns, fire control calculators, submarines, radios, and oil-fired engines were introduced.

Aviation gradually acquired *bureaucratic* standing within the Navy. In 1908 the Bureau of Equipment authorized purchase of aircraft for experimental use (largely for spotting). In 1910 the Secretary of the Navy designated an advisor for aviation matters. At the same time the influential General Board—composed of active and retired flag officers—advised the Secretary that space for aircraft should be provided in future scout

by 1916 both the U.S. Army and Navy were aware of the growing usefulness of aircraft

ships. The Chief of the Bureau of Steam Engineering also told the Secretary that aircraft would play a major role in naval operations and recommended that some Navy officers be taught to fly.

Noteworthy *technological* events occurred. Eugene Ely made the first takeoff from and landing on a ship in 1910–11. Glenn Curtiss demonstrated the first successful seaplane. However, aircraft were generally poor in quality and often crashed or were inoperable. *Organizationally*, in 1913, on recommendation of the General Board, the Navy established an organized air service. It noted that “an air fleet . . . had become a necessary adjunct to the Navy.” By 1914 there was a Director of Naval Aviation who routinely testified before Congress.

Key individuals like Henry Mustin and John Towers, both of whom served as battleship spotters and were aware of the fire control problems of long-range gunnery, learned to fly. By 1914 they were commanding officer and executive officer respectively of the Pensacola Aviation Training Center, established to help organize an air service. There they met Captain W.S. Sims when his squadron stopped en route to Mexico and induced him to take along three seaplanes on a cruiser. Sims had already made a name as an innovator and reformer after successfully opposing the vaunted Mahan over a question of gunnery and ship design.

External Environment

Meantime in the industrial sector, aircraft development was crippled by prolonged litigation over patent rights held by Orville and Wilbur

Wright and by Glenn Curtiss. The suit involved the issue of whether the development of Curtiss ailerons infringed on Wright wingwarping technology for turning aircraft. In consequence, as America’s entry into World War I approached, Army and Navy air requirements could not be met by the civilian sector.

By 1914 European aircraft performance, more advanced than in America, led to expanded military operations. The war offered great incentive for improving performance and opportunity to see what worked and what didn’t. By 1916 both the U.S. Army and Navy were aware of the growing usefulness of aircraft and their own lack of air readiness. In response Congress approved increased funding for aircraft and expansion of training operations at Pensacola. It also permitted the Navy to establish a separate Naval Flying Corps. The Secretary of the Navy further suggested building a naval aircraft factory to develop prototypes and provide test data on costs and schedules to industry.

Air operations in 1917–18 foreshadowed key uses of airpower in World War II. Aircraft were increasingly employed to provide close air support, defend against zeppelin bombing raids, bomb military targets such as sub pens and air bases, and prevent an enemy from doing the same.

At sea, the Royal Navy converted several ships to carry airplanes and towards the end of the war constructed “built-for-purpose” carriers. Their operational roles were scouting and reconnaissance and attacking land targets. There was no thought of using aircraft against the German fleet at sea, largely because the ordnance was not considered powerful enough. The British also conducted shore-based operations, including zeppelin defense and coastal antisubmarine warfare patrol.

The war revealed the relevance of aircraft to accomplishing military tasks. This influenced many key individuals, not all naval. Leaders such as Douhet, Trenchard (Royal Flying Corps, later head of the Royal Air Force), and Mitchell (head of aviation for the American Expeditionary Force) were convinced that mass destruction of targets by bombing would render static land warfare unnecessary. In Britain the Royal Air Force was formed as a separate service in April 1918. In the United States Mitchell’s advocacy of strategic bombing and a separate air force stimulated developments in the Navy as well as the Army. Naval officers such as Sims and Mustin returned from Europe also convinced of the effectiveness of aircraft but with a different focus.

British and American officers worked closely together in 1917–18. Their collaboration was evidenced by the fact that a Royal Navy constructor provided the latest British carrier designs to the United States in late 1917. Yet almost immediately

after the war British and American carrier development diverged. Indeed there was considerable Anglo-American rivalry during the interwar period so that particularly in the 1920s there was little occasion to share successes and failures.

Comparative Experiences

The Royal Navy had the only carriers in 1919 and were far ahead in carrier aviation. Senior officers wanted a dozen to support a large battle fleet. Based on their wartime experience, they had definite ideas on missions: scouting, spotting, fighting, and torpedo attack as well as air group composition. *Institutional acceptance* of carriers as an integral part of the battle fleet was much greater among senior British officers than their American counterparts. This was likely due to the Royal Navy having very recent experience with combat at sea and with actual use of carriers.

But political and budgetary constraints soon made it clear that there would be no large postwar battle fleet. In early 1919 the cabinet adopted a "10-year rule" that envisioned no major war for a decade and was the basis for drastic cuts in defense. In particular, construction of most large ships was canceled, including battlecruisers equal in size to *USS Lexington*. Nonetheless, in July 1920 the Admiralty Staff Conference released a report calling for at least five carriers, three for the home fleet and two for overseas commitments and refitting. This helped drive later negotiations on carrier limits in the Washington Naval Treaty of 1922.

Organizationally the Royal Naval Air Service was subsumed under the Royal Air Force in 1918. The navy was effectively deprived of 60,000 aviation experts. This would have severe repercussions for British naval aviation.

In America aviation issues exploded into public and congressional consciousness in 1919. Mitchell told the Navy General Board that a unified air service was inevitable and informed Congress that air forces would supersede navies as the first line of defense. A former commander of naval forces in the Pacific, Admiral William Fullam, published an article suggesting that aircraft would become independent strike weapons beyond their use as gunnery spotters and scouts. Sims, now president of the Naval War College, further incited the debate by charging that the Navy—including its air component—was unready in 1917. Many wrote about military aviation, but it appeared to be the public testimony of senior champions that forced the issue to the forefront.

In late 1920 the Navy conducted confidential bombing tests against an obsolete battleship well before the more famous 1921 Mitchell tests. *The New York Times* obtained damage photos and called for "a free and thorough discussion as to the effect of new weapons upon naval warfare."

In subsequent congressional testimony Mitchell again argued for a unified air service, claimed aircraft could sink ships, and charged that the Navy did not devote sufficient attention or resources to its air units. In response the General Board argued that the Nation could not afford to abandon battleship-based forces in response to "mere theories as to the future development of new and untried weapons." That was partially undercut by senators such as William Borah (a champion of new naval technology including aircraft) and officers such as Fiske, Fullam, and Sims. When Sims testified in 1921 that he "would not abandon battleships altogether," he was certainly less than confident about their future role. The issue was particularly salient because construction of battleships authorized on the eve of the war continued.

Organizationally, the Bureau of Aeronautics was formally authorized by Congress in July 1921. Its first chief, Rear Admiral William Moffett, a key individual, immediately formed a staff of experts including future flag officers such as Bellinger, Radford, and Land. Soon after, Admiral Sims wrote Moffett to stress the importance of close organizational cooperation with the Naval War College, which was crucial in developing naval aviation, as was the bureau's involvement with both academe and industry.

External Environment

After the war the prospect of an expensive naval arms race between the U.S. and British navies dismayed both nations and provided the impetus for an arms control conference. In 1921 President Harding was elected on a platform which contained a popular naval disarmament plank. When the Washington Naval Conference of 1922 was announced, it became clear that battleships authorized in 1916 and still under construction would not be completed. Although the conference focused on battleships, it placed quantitative and qualitative restrictions on carrier tonnage. Among other provisions, America, Britain, and Japan were each allowed to convert two battlecruisers into carriers. This would have differing effects on carrier forces, particularly by limiting experimentation with carrier forces, which directly affected carrier design.

The restrictions were not at first perceived as significant obstacles since for the signatories it was a question of building up to the limit. The British understood that their carrier designs were unsatisfactory. Both treaties permitted scrapping them and building other carriers to the negotiated limit, but political and economic realities

would later preclude it. The treaties also created expectations about progress in disarmament and naval arms control. That contributed to a climate in which it became difficult to convince America and Britain to buy “unnecessary” items such as additional carriers or, in the Royal Navy, scrapping extant carriers for newer ones which incorporated lessons learned.

The British had four carriers in 1922, but because of the 1919 halt in capital ship building they had no large battlecruiser hulls to convert. Instead they used cruisers, *HMS Courageous* and *HMS Glorious*, which had small aircraft capacity and limited space to accommodate larger aircraft.

In the United States, treaty restrictions—coupled with tight budgets and the availability of large battlecruiser hulls that would otherwise have been scrapped—led to selecting *USS Lexington* and *USS Saratoga* for conversion. Being the furthest along in construction, they would entail the least cost. The

availability of these hulls would be fortuitous for diverse unanticipated reasons. They could accommodate many larger and heavier aircraft, support more ordnance and aviation fuel storage, and operate in bad weather. That contrasted with the limits the Royal Navy would find in

smaller carriers. But the conversions were slow and expensive, with neither ship becoming available until 1927. How could carrier aviation concepts be tested in the interim? The answer was found in part at the Naval War College.

Naval War College

In 1919 Admiral Sims initiated a process whereby the potential of naval aviation could be established systematically through tactical and strategic *simulations*. He sought to address how aviation should be based, supported, and might be used given the anticipated developments in aeronautics. Sims guided a rigorous refining of two kinds of games. The first, strategic in nature, were called “chart maneuvers” and explored the issues of a war with Japan. The second, tactical, were “board maneuvers.” They were conducted on a large tabletop and compared the military value of different tactical formations, offensive and defensive concepts, and force mixes.

Sims noted the importance of connecting wargaming rules with actual data and conditions: “Air tactics are of utmost concern to the college, and only from actual work done in the field can we hope to formulate definite and sound ideas concerning them.” Furthermore he noted: “In operating aircraft in chart maneuvers and game board exercises, various rules are applied which must of necessity be in close agreement with actual conditions if the true value of aircraft to the

fleet is to be appreciated.” And writing in 1922, Sims stated: “If the rules of the game are not right . . . the conclusions drawn from the maneuvers are sure to be erroneous.”

To square simulations with experience, the faculty regularly corresponded with aviators in the fleet to stay abreast of lessons learned from actual operations. Game results were often verified by experience from fleet problems. With the establishment of the Bureau of Aeronautics a similar exchange developed. The bureau supplied projections on the technical performance characteristics of future systems and the college helped evaluate ship and aircraft designs.

The Naval War College played other roles in fostering aviation. It contributed to scenarios used in fleet problems and supplied ideas to be tested in the fleet. One example is the circular fleet formation devised by Commander Chester Nimitz and successfully introduced to the fleet in 1923. This symbiotic relationship gave Newport substantial credibility in testing concepts through simulation absent real opportunities to do so. The college was also the forum through which officers were exposed to and forced to consider the implications of airpower. Seminal papers by Moffett, Mustin, and others were regularly presented. Since attendance at Newport marked mid-level professional success, students returning to the fleet in senior ship and staff positions had a growing appreciation of aviation. That influence was bolstered in 1925 when Admiral Coontz advocated to the Chief of Naval Operations that “all students at the U.S. Naval Academy be given a course in aeronautics” and that although “all graduates may not be able to qualify as . . . naval aviators, the great majority can . . . become familiar with . . . the offensive and defensive employment of aircraft.”

In simulations the Naval War College examined various operational and technical problems and questions. Most interesting were simulated carrier operational concepts. Between 1920 and 1925, a number of tentative conclusions based on these were reached:

- The Lanchester model of battleship effectiveness did not apply to carriers. The former delivered ordnance in steady streams while carriers delivered “pulses” of power.

- Carriers, once in range of an enemy, were to strike immediately. It was also essential that the first targets be enemy carriers in order to gain air superiority over an enemy fleet.

- The key measure of effectiveness (MOE) for carrier strike was numbers of aircraft in the air, presumably because the amount of ordnance available was a direct function of that. Naval War College studies in the early 1920s suggested that strike potential was maximized when aircraft were launched quickly from a number of smaller carriers.

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USS Saratoga.



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■ Carriers had many weaknesses. They had to be close to enemy formations to launch and recover planes due to the short range of bombing aircraft. Moreover, wind direction dictated the general flight operations course.

Practical Experience

In 1924 the Navy established a Special Policy Board of the General Board. It was directed to consider the status of aircraft and the future of the battleship. The board consulted aeronautical authorities including the National Advisory Committee on Aeronautics which indicated that aircraft "maximum performance . . . may be increased about 30 percent by future developments." That modest projected growth and the lack of practical experience and verification of ideas suggested in the Naval War College simulation caused the board to recognize the battleship

as the prime means of delivering ship-killing ordnance. But the board did not so much reaffirm battleship dominance as it recognized the uncertainty of aircraft as strike weapons. This was supported by recommendations from the Chief of Naval Operations for steady funding of aircraft programs, conversion of both *USS Lexington* and *USS Saratoga*, as well as authorization for a built-for-purpose carrier.

These events pressured the Navy to demonstrate the practicality of the ideas pushed by naval aviators and supported by simulations. Proponents knew they had to show results both to fend off demands for an independent air service and to influence Navy resource allocation issues.

A key individual, Captain J. M. Reeves, now entered the story. He arrived at Newport in spring 1924 and for the next year headed the tactics department with responsibility for simulations. He then took a "catch-up" observer course for non-aviators at Pensacola. The Chief of Naval Operations appointed Reeves commander of Aircraft Squadrons, Battle Force, in September 1925 which gave him an organizational role. A month later he was directed by the commander in chief, Battle Fleet, to develop "strategy and tactics of the air in its relation to the fleet." Thus the theoretician/wargamer was given resources and official encouragement to experiment and test ideas freely in the field.

Reeves started with the simulation conclusion that the number of aircraft in the air was the key MOE for strike effectiveness. His problem was how to maximize that number. For him, the technical problem of the carrier air strike concept was how to reduce the long per-plane launch/land times. He examined the launch/land process in detail. Before, each plane was put below after landing in case the next one missed the arresting wires and crashed into those on deck. Reeves invented a movable deck carrier, which obviated the need to move to and from the hangar deck. Once all planes were recovered, they were moved aft, refueled, rearmed, and ready to launch.



U.S. Navy

DT-2 from USS Langley with torpedo and rigged parachute, 1926.

By August 1926 Reeves recommended that the official status of USS Langley be changed from experimental to "full-fledged combatant" and that its complement of aircraft be doubled to 28. A year later his successor reported, "Commander Aircraft Squadrons believes that he can operate in time of war 48 planes from the carrier."

From mid-August 1926 aviators on board USS Langley were "devoted to intensive study by practical operations of aircraft tactics." One *innovative tactic* examined was dive-bombing, which seemed to address the problem of accurately hitting targets (though it was unclear that this was a purely Navy development). In October 1926 Reeves had a squadron of aircraft carry out such an attack on an alerted battleship squadron. It was witnessed by the fleet commander in chief, Admiral Hughes, who promptly became a strong proponent of naval aviation. By December the accuracy of steep

dive-bombing, later used throughout World War II, was established (though it was not clear that the method would kill ships given the weak ordinance of the period). Contemporary reports also noted more combined dive-bombing and torpedo *tactics* against ships armed with antiaircraft guns.

These developments had an organizational consequence. Reeves' old job as commander, Aircraft Squadrons, Battle Force, became a flag billet in September 1927.

American Developments

Admiral Moffett, reappointed chief of the Bureau of Aeronautics in March 1925, was the Navy's point man in the political battle against General Mitchell and his congressional supporters. He approved publicity including risky non-stop seaplane flights between California and Hawaii as well as visits by the airship *Shenandoah* across the country in September 1925. Both events ended with fatal accidents and were cited as evidence of Mitchell's charges of naval negligence and incompetence (which soon culminated in his court-martial).

In response, President Calvin Coolidge created the Morrow Board to examine the future of aviation and government involvement. After lengthy hearings the board rejected the idea of a unified air service and unified aircraft procurement. It called on Congress to authorize procurement of 1,000 planes over five years to sustain the aircraft industry and provide the Army and Navy with modern planes. It also recommended that aircraft carriers and naval air stations be commanded by naval aviators. The motivation for the last item is unclear. Did the board conclude that such assignments required knowledge possessed only by aviators, or that viable command and career opportunities should be provided for aviators? Giving ship command to aviators would bestow greater institutional acceptance by the then-dominant, more traditional surface warfare community.

In mid-1926, the Battle Fleet commander in chief noted that there was "a lack of statistical tactical data in connection with aerial operations and . . . of any system or well-defined doctrine for the employment of aircraft in major operations." At the same time, the Bureaus of Aeronautics and of Construction and Repair differed on the design of the built-for-purpose carrier recommended by the 1924 Special Policy Board. The General Board asked the Naval War College for assistance.

Simulation in 1926–27 specifically addressed issues dividing the Bureaus of Aeronautics and of Construction and Repair. The staff of the Naval War College determined that it was essential that carriers be able to arm and service planes on deck rather than exclusively in the hangar and that

they have open ventilated hangar decks for servicing which precluded interference with flight deck operations. It later specifically recommended construction of “large high-speed vessels, probably of 23,000 tons and 33 knots.”

In June 1926 Secretary of the Navy Curtis Wilbur postponed further construction pending exercises scheduled to take place after the commissioning of *USS Lexington* and *USS Saratoga* in 1927. Moffett unsuccessfully objected, arguing

loss of aviation personnel separated the Royal Navy from wartime lessons

that a delay would put the Navy at a disadvantage vis-à-vis Britain and Japan. The Secretary agreed to revisit his decision after the December 1926 dive bombing demonstration and rigorous analysis by the Naval War College as noted above. He established a special review board to weigh new evidence. The instructions to the board stated that it was “necessary to assume certain risks in the purchase of new equipment and be willing to assume these risks if we expect to advance.”

Moffett persuaded Rear Admiral David Taylor to include Moffett, Reeves, and Captain H.E. Yarnell (the future first commanding officer of *USS Saratoga*) as board members. The review quickly found that the key issue was what kinds of aircraft to put on carriers. Congress had acted on the recommendation of the Morrow Board and authorized procurement of 1,000 planes over five years. But what kind?

The board suggested that acceptance of carrier aviation as a primary strike weapon was far from universal. It rejected the concept of a single scout/fighter/bomber and identified six priorities:

- fighter planes
- battleship/cruiser spotters
- scout/reconnaissance planes
- dive bombers
- level bombers
- torpedo planes and patrol seaplanes

The priority given to fighters and spotters suggests that carrier aircraft were primarily seen by the board as the means of achieving air superiority for spotting during engagements between battleship forces. The board had the luxury of considering multiple specialized aircraft because of the large congressional authorization. Otherwise it might have been forced to decide which types to recommend and hence made a skewed selection not necessarily based on operational tactical requirements.

British Developments

Organizationally, establishment of an independent Royal Air Force had pernicious effects, both direct and indirect. Those were aggravated by financial problems. The service had to justify

its existence under severe budgetary constraints, relying heavily upon strategic bombing doctrine, which it argued supplanted many roles formerly carried out by armies and navies and at lower cost. This came to be called “air substitution.” The Royal Air Force consistently convinced Whitehall of the merits of its case, which further constrained other service budgets. In particular, the Royal Navy was unable to replace outmoded aircraft carriers until the late 1930s. The Royal Air Force, largely responsible for procuring naval aircraft, bought as few as possible in order to buy more aircraft for its principal strategic bombing mission. This further militated against acquiring more or larger carriers to accommodate more aircraft.

There were other organizational consequences. Loss of technically-minded aviation personnel effectively separated the Royal Navy from its corporate memory of wartime lessons. All naval links with the aviation industry were cut. There was no mechanism for institutionalizing aviation in the service. There was no way to establish bureaucratic equivalent of the Bureau of Aeronautics. All this made it impossible to conduct any significant study of the future role of naval aviation.

The loss of naval aviators who believed in carrier potential eliminated the counterweight to the gunnery community. Coupled with dramatic increases in the effectiveness of surface gunnery (with spotting aircraft) in the 1920s, that materially affected conceptions of how aircraft should be used. While the navy did reestablish a Fleet Air Arm with junior officers in 1921, it strongly resisted separateness. Aviators served alternate tours between Fleet Air Arm and the rest of the Royal Navy. Nonaviators commanded carriers because good seamanship was the key aspect of command. The practical effect was that no “band of committed enthusiasts” could form an internal lobby.

But Royal Navy carrier development was not hindered by organizational problems alone. The technical aspects of British carrier design were deficient in ways that had a cascading effect. Carriers were by nature expensive, durable ships; thus design decisions had long-lasting consequences. Moreover, those decisions also dictated key aspects of carrier aircraft design. Consequently, development of carrier aircraft in the 1930s was heavily shaped by carrier design decisions made long before much operating experience had been acquired. Since aircraft were then relatively short-lived, particularly during a period of rapid technological change, there was a premium in having large carriers with large margins for accommodating newer aircraft and their support requirements. Both America and Japan had large hulls which could be converted into carriers while Britain did

not. The other way to accommodate unforeseen changes in requirements was with a budget that allowed for replacements, a luxury Britain lacked. Even when the coming war resulted in much greater defense spending, urgent competing priorities permitted only one additional carrier to enter the fleet prior to 1940, while urgent Royal Air Force defensive requirements limited production resources available for improved naval aircraft.

One key early technical judgment bedeviled British carrier development. The Royal Navy did not adopt carrier deck parks; when not engaged in flight operations, aircraft were stowed below. Thus hangar size became a determinant of carrier aircraft capacity and characteristics and drove operational cycle times. The hangars were closed rather than open, so aircraft engines had to be warmed up on deck. But hangar size was impossible to alter after the fact. Another major problem was limited aviation fuel storage and inability to retroactively install special fuel tanks. Even had aircraft capacity been increased, it would not have been possible to support the larger airwing. This problem only got worse as more powerful engines were developed. Flight deck gear was sadly deficient. The Royal Navy did not install an effective deck barrier until 1939. This affected flight operations because aircraft required more deck space for launch and landing, which drove an apparent requirement that aircraft be below between landings and brought up sequentially for launch. Since this procedure was key, carriers could not expeditiously launch large strikes. Moreover, since the British could not see how to overcome this problem they presumed other navies had a similar one. Admiralty documents dismissed claims about American aircraft capacities into the 1930s. Flight deck limits also imposed key technical features on aircraft design including slow launch and landing speeds. These technical requirements conflicted with desirable tactical characteristics. That was not crucial in the biplane era, but the Royal Navy was unable to modify ships to accommodate the powerful monoplanes of the mid-1930s.

Unlike America and Japan, Britain did not confront a major naval enemy in home waters. By the 1930s the threat seemed to be a small Italian fleet and a handful of powerful German surface ships. In dealing with it, Royal Navy thinking was heavily influenced by World War I. The operational problem bedeviling the British then was reconnaissance. Since the Royal Air Force controlled all landbased aircraft and stressed strategic bombing, the Royal Navy did not have long-range, land-based patrol planes for maritime reconnaissance. Carriers required their own

search aircraft which meant extra crew for navigation at sea and, in turn, reduced aircraft performance. Moreover, search area coverage determined the number of scouting aircraft embarked, which in turn became important relative to aircraft capacity.

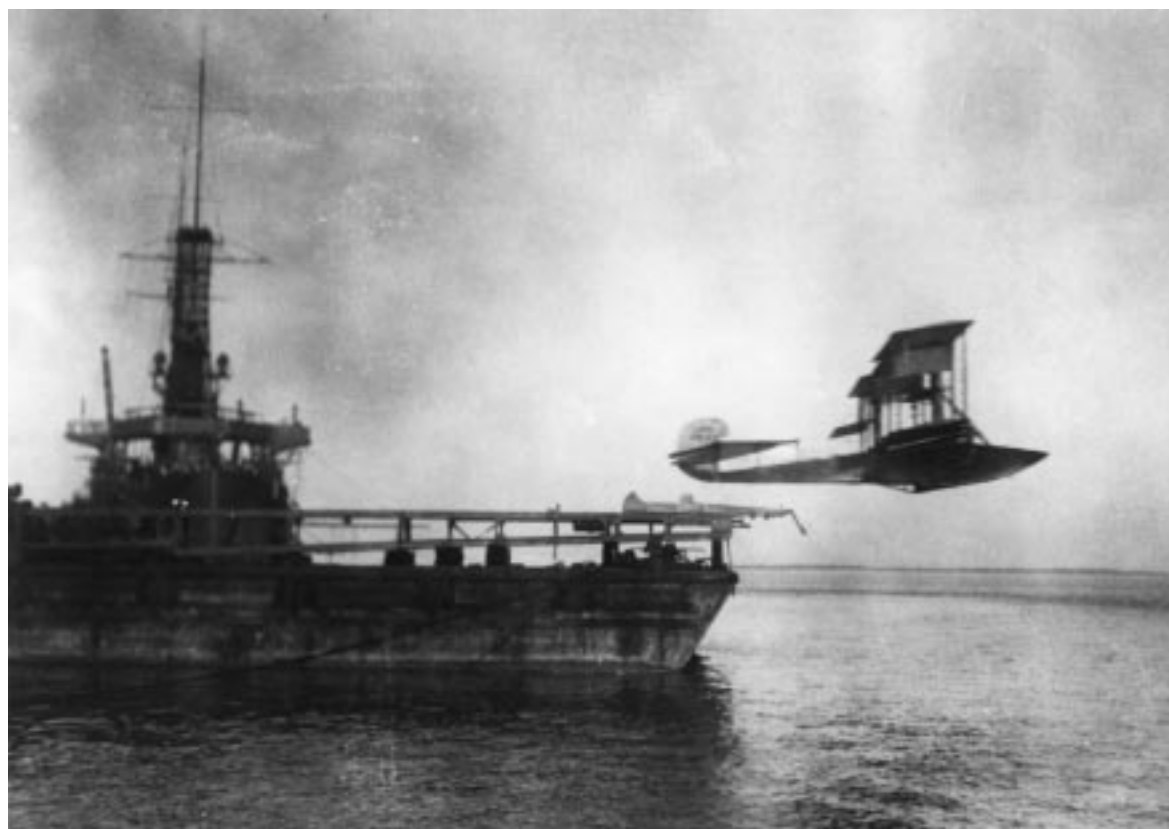
British officers never developed the vision of carrier strike that Mustin and Reeves had on the American side. The dominant concept was that the battle line would win the decisive battles. The lessons of World War I, particularly Jutland, drove thinking on aircraft. Once reconnaissance planes located an enemy fleet, it had to be prevented from eluding the battle force. Torpedo attack by aircraft was regarded as the best way of slowing an enemy to allow the battle line to destroy it, with spotter aircraft and long-range gunnery. The fighter role was protecting vulnerable spotters. Ironically, the Royal Navy studied the question of battleship vulnerability to aircraft repeatedly during the 1930s but did not consider it a serious problem, at least until December 1941.

The focus by the Royal Air Force on strategic bombing not only contributed to neglect of naval aviation but rejection of the role of close air support for the army. Dive bombing was thus not explored, leaving the Royal Navy unable to experiment with a technique that had the potential to deliver ordnance against ships without virtually assured destruction of the delivery aircraft.

These tactical considerations, coupled with the technical limitations and requirements noted above, led to deployment of multi-purpose planes (because of space limitations) with two or three crew (due to navigation and observation requirements) and poor performance (from mandated low launch/landing speeds and added crew weight) save for exactly those features which the Royal Navy considered most important for tactical purposes—long range/endurance for scouting and, for torpedo planes, carrying heavy weapons. Indeed, in the mid-1930s it depended largely on a single aircraft type to do reconnaissance, spotting, and torpedo attacks. Its fighters did not have to be high performance since the Royal Navy did not anticipate a fleet action in range of land-based aircraft; and from experience it projected that all naval aircraft were inherently low performance. Some British fighter designs were even multi-mission.

Thus perversely, the Royal Navy carefully considered what it wanted carrier aircraft to do tactically and thoroughly integrated them. In 1931, for example, one British publication noted that although America was “considerably ahead of our Fleet Air Arm in the techniques of operating aircraft from catapults and carrier decks, their efficiency in reconnaissance is not up to our current standard.” In the early 1930s the Royal Navy

Launching seaplane at Pensacola in 1915.



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apparently had no reason to believe it was mistaken; it assumed the limitations it faced were universal, did not believe many American claims, and lacked mechanisms for critical analysis. In particular, there was no budget to procure modern carriers and aircraft, no technical staff to work with industry and test aircraft designs, and no method to weigh operational concepts for employing carrier aircraft. When the Royal Navy realized how far behind its Fleet Air Arm was it was too late to recover. Wartime carriers lacked the punch of their American counterparts and many British air groups flew U.S. aircraft.

Only in the late 1930s could Britain do what Reeves and *USS Langley* had done in 1927. Given the different evolution of its carrier aviation, the Royal Navy was never able to consider the next step in carrier development—multiple carrier operations. The U.S. Navy, on the other hand, had been simulating such operations since the early 1920s and exercising them since 1929.

Multiple Carrier Operations

For the U.S. Navy the problem of launching the maximum number of aircraft from a single carrier was nearly solved by the end of 1927. Specific technical issues such as limiting aircraft damage from arresting gear, refueling aircraft on

flight and hangar decks, and moving planes on deck at night and in bad weather needed to be refined, but the main problem had been addressed. However another problem—at the center of the carrier revolution—remained: how should multiple carriers be used?

By early 1927 Reeves already had the notion of employing multiple carriers as the core of a fast-striking force and argued for concentration. Based on the wargames in 1926–27 at Newport, he was convinced of the need to deliver a knockout blow against enemy airpower in the opening minutes of any confrontation between carrier forces. This again implied that carrier aircraft could kill carriers. Whether that meant sinking them or merely rendering them incapable of air operations by, for example, punching a hole in their wooden decks was not clear.

USS Lexington and *USS Saratoga* were commissioned in 1927 but had problems requiring a year to fix, including how to run a deck park with more than the handful of aircraft *USS Langley* operated. The ships finally prepared to go to sea for Fleet Problem IX in 1929, the initial test of multiple carriers launching significant numbers of aircraft. Each ship had over a hundred planes. The large

aircraft complement allowed great flexibility, especially when compared with Royal Navy carriers.

In Fleet Problem IX, *USS Saratoga*, with Reeves in command, detached from the main force and made the famous dive-bombing raid on the Panama Canal, though archival records indicate that *USS Saratoga* was detached from the battleship force only because the destroyer escorts lacked the fuel to keep up. There was no intention for the carriers to operate as an independent strike force. Admiral Pratt, commander in chief U.S. Fleet, did not consider the exercise realistic enough to draw major lessons from it.

The aftermath was interesting, however. This problem was followed by a critique presided over by Pratt. The force commander of the *USS Saratoga* group noted, "When we learn more of the possibilities of the carriers, we will come to an acceptance of Admiral Reeves' plan which provides for a very powerful and mobile force . . . the nucleus of which is the carrier."

Carriers were accepted as fleet units. A Bureau of Navigation requirement that line officers pass detailed exams on naval aviation and aircraft characteristics was evidence of institutional acceptance. Yet carriers were not seen as independent strike platforms outside the naval aviation community. As Commander John Towers told the General Board in late 1929, "We can't drop a 500-pound bomb on a battleship."

Debate ensued over carriers as independent strike forces versus their role supporting the battle line. Focus on the strike mission meant fewer de-

fensive assets over the battleship assets they supported. This question was never satisfactorily addressed during the 1930s, in part because of the scarcity of carriers and limited aircraft capabilities. Moreover,

little thought appeared to be given to multiple carrier employment—especially when aircraft performance improved—because of restrictions imposed by the Washington Naval Treaty and political considerations. The Naval War College simulation-fleet empirical testing failed to work as well as it had in the 1920s.

With respect to treaty constraints, the Washington agreement limited total carrier tonnage. By choosing to convert *USS Lexington* and *USS Saratoga*, the Navy had little tonnage for follow-on carriers, reflected in the unsatisfactory design of the light carrier *USS Ranger*. It was not possible to build many large (as opposed to light) carriers to

test operational concepts. But it is not clear what might have happened without the treaty—many more battleships might have been built or Congress might have approved the wrong type of carrier. The Taylor Board recommended in 1927 that five 13,800-ton carriers of *USS Ranger* type be built. Had that actually occurred, the United States might have found itself stuck like Britain, with platforms that could not easily accommodate subsequent developments. At the same time, given that the key metric was aircraft in the air, such a choice was not obviously wrong. Congress saw no reason to increase the number of carriers while further limits were being considered for the 1930 Geneva talks. By the early 1930s economic distress further constrained military spending.

The fact that gaming at Newport did not significantly affect carrier aviation in the 1930s is puzzling. Because the lack of existing assets to test single and multiple carrier propositions did not preclude Newport from simulating them in the 1920s, one can ask why multiple carrier operations were not analogously simulated in the 1930s. Whether gaming and fleet exercise interaction on carrier operations continued, the fact remains that in 1941–42 the Navy tried to answer questions by trial and error which ostensibly lent themselves to prior simulation. Should multiple carriers operate singly or in task groups? How should air groups be composed? With respect to fighter interception, how can enemy bombers be detected and effectively attacked?

Nonetheless, there was progress in developing carrier aviation during the 1930s. Moffett, of the Bureau of Aeronautics, and Chief of Naval Operations Pratt consistently argued before the General Board that the aim of naval aviation was to "bolster the offensive power of the fleet and of advanced base expeditionary forces." As Moffett stated, "The primary function of the main body of carriers is certainly to increase the major attack power of the fleet. . . ." The mid-1930s fast battleship design offered the promise of combined carrier-battleship strike forces.

One barrier to recognizing strike effectiveness was the relative impotence of carrier aircraft as a strike weapon. In the 1930s dive bombers could deliver two 100-pound bombs, and torpedo bombers could carry a 2,000-pound torpedo but were highly vulnerable to fighters and anti-aircraft gunnery because of their bombs. The problem was that carrier aircraft were not yet shipkillers.

The solution was found partly in more powerful engines. World War I had shown that fast, rapidly climbing fighters had a tactical advantage. It was assumed that U.S. carrier fighters would inevitably engage land-based Japanese aircraft, but the need for strong engines was not only driven by military needs. Commercial aviation expanded

little thought appeared to be given to multiple carrier employment because of the Washington Naval Treaty

*USS Shaw exploding,
December 7, 1941.*



U.S. Navy

rapidly. While the 1920s saw civil aircraft largely used for barnstorming and mail service, reliable instrument flying and an expanding infrastructure made air transport viable and created a demand for high performance aircraft and engines which led to a profitable industry.

Institutionally, the Bureau of Aeronautics (and the Army) fostered development of aircraft technologies by industry, including radial engines and aeronautical streamlining. Military and civil requirements reinforced each other. Performance rapidly improved throughout the decade until, by 1937, the SBC-4 dive bomber carried a 1,000 bomb almost 600 miles with a maximum speed of 237 miles per hour with interesting technical results. These required greater takeoff and landing speeds. That validated the need for greater takeoff and landing speeds or longer distances. Higher performance drove up fuel consumption and called for added fuel storage capacity. These factors had obvious implications for carrier design. Again, the fortuitously large size of *USS Lexington* and *USS Saratoga* accommodated these developments. The Royal Navy was not so fortunate.

There were also operational consequences. Carrier aircraft could now deliver ship killing ordnance. For scouting purposes, greater speed and longer range permitted faster searches of far larger areas. Moreover, range could be traded for payload, allowing scouts to carry bombs and a given aircraft to perform different missions, thus influencing air group composition. It also meant a radio-equipped scout could detect an enemy, report its position, and attack immediately. Given the imperative to strike enemy carriers at once, this was an important capability.

The cumulative effect of these developments was that the United States possessed a potent albeit latent strike capability by 1941. It was latent because, although individual carriers had some of the capacity envisioned by Reeves during trials on *USS Langley*, the concept of multiple carriers as an independent striking force remained untested. Moreover, there was little sign that aviators themselves consistently held that vision, judging by early carrier operations in 1942.

The Japanese attack on Pearl Harbor was the first operational use of carriers as foreseen by Reeves (the Royal Navy raid in 1940 on Taranto was conducted by a single carrier). Strikingly, the U.S. Navy took some time to follow the enemy lead. Despite the devastating Pearl Harbor raid and other Japanese operations, the Navy fought in single carrier task groups for another year. Even at Coral Sea, Midway, and Guadalcanal, task groups were split (except for *USS Hornet* and *USS Enterprise* at Midway). It was only after the experiences of 1942 that multi-carrier task groups became the fleet standard. By then the ability of carrier aircraft to kill ships and defend carriers was incontrovertible as was the vulnerability of battleships to air attack. The revolutionary effects of naval aviation had become clear. JFQ

This article is directly based on a study entitled "The Introduction of Carrier Aviation into the U.S. Navy and the Royal Navy: Military-Technical Revolutions, Organizations, and the Problem of Decision" by Thomas C. Hone, Mark D. Mandeles, and Norman Friedman, which was conducted for the Office of Net Assessment within the Office of the Secretary of Defense in July 1994. A book-length version of the original study will be published by U.S. Naval Institute Press.