Crashed VE–7 on *USS Langley*, 1925.

Naval Historical Center

Military Innovation and Carrier Aviation— An Analysis

USS Langley leading task group in the Philippines, 1944.

Naval Historical Center

By JAN M. VAN TOL

The first part of this article, which appeared in the last issue of *JFQ*, charted the historical development of British and American carrier aviation, with particular emphasis on the complex interplay of technological, operational, and organizational factors. The second part treats key questions on how this revolution succeeded in the U.S. Navy and was rather less successful in the Royal Navy and what that implies for military innovation. Among questions considered are:

- How quickly did those who grasped the vision move from a vague to a clearly-defined vision? How quickly did change take place?
- Which mattered more to making progress, individuals or groups?
- What were the barriers to change and how were they overcome?
- Did change depend on having a particular enemy?
- How important was competition?
- How important was a consciousness of the new concept's potential?

Naval Historical Center

Mustin (fourth from right) at Pensacola, 1914.

Then and Now

What was it like to be a junior officer following World War I? An aviator? A senior naval officer vis-à-vis a carrier aviator? Most junior officers who sought naval careers considered which specializations were best for advancement. Many officers wanted to minimize professional risk.

Perceptions of present and future relevance minimized that risk. In the early 1920s, there was ample evidence that aircraft could do militarily interesting things at sea. While proponents of aircraft as independent strike weapons were a minority, aviators were already well accepted by the commanding officers of ships. Flying was not regarded as a bad tour, though it is noteworthy that most aviators continued to do traditional shipboard tours.

legislation requiring commanding officers of carriers to be aviators created career paths

Risk was further reduced by establishing an institutional home for champions and a venue for experimenting with new capabilities and concepts of operation. This led to a viable career path that kept officers employed when their few years of flying ended. (There were inevitably too many pilots for the available senior billets. There was concern over the future of aviators who were not selected to be commanders or executive officers.) The establishment of the Bureau of Aeronautics in 1921 and the legislation passed in 1925 requiring commanding officers of aircraft carriers, seaplane tenders, and naval air stations to be aviators created career paths.

The British case was simpler. If one wished to fly during the interwar period he joined the Royal Air Force where advancement was based on belief in the strategic bomber. Maritime flyers were not usually on a fast track. Even after reestablishment of a Fleet Air Arm, aviation duty was something separate from principal shipboard duties. In short, in the Royal Navy there were better ways to the top than through aviation.

Bureaucratic factors, while perhaps necessary, were not by themselves sufficient to ensure the future of aviation. On personal and intellectual levels in the 1920s, there was great enthusiasm over technology, particularly in the field of aviation. Prominent in the accounts of this period was the sense of adventure among those who wanted to fly. The newspapers were filled with stories of barnstorming and aviation firsts. Together with images of aviators as the only glamorous warriors of World War I, this inevitably made flyers an elite group in the eyes of the public.

There was professional excitement as well. The debate over the role of airpower generated by General Billy Mitchell, the media, and others was prolonged and serious if raucous. Many of the propositions about airpower were *prima facie* not trivial, including questions about the future viability of battleships. Other events such as the mass production of automobiles and expansion of electricity, if not directly relevant to aviation, further stimulated interest in technical solutions and applications. All this suggested in the early 1920s that naval aviation had a future of its own.

Commander Jan M. van Tol, USN, is commanding officer of *USS O'Brien* and formerly served in the Office of Net Assessment within the Office of the Secretary of Defense.

Whiting (third from left), 1918.

Naval Historical Center

Flying-off platform on turret of *USS Arizona*, 1921.

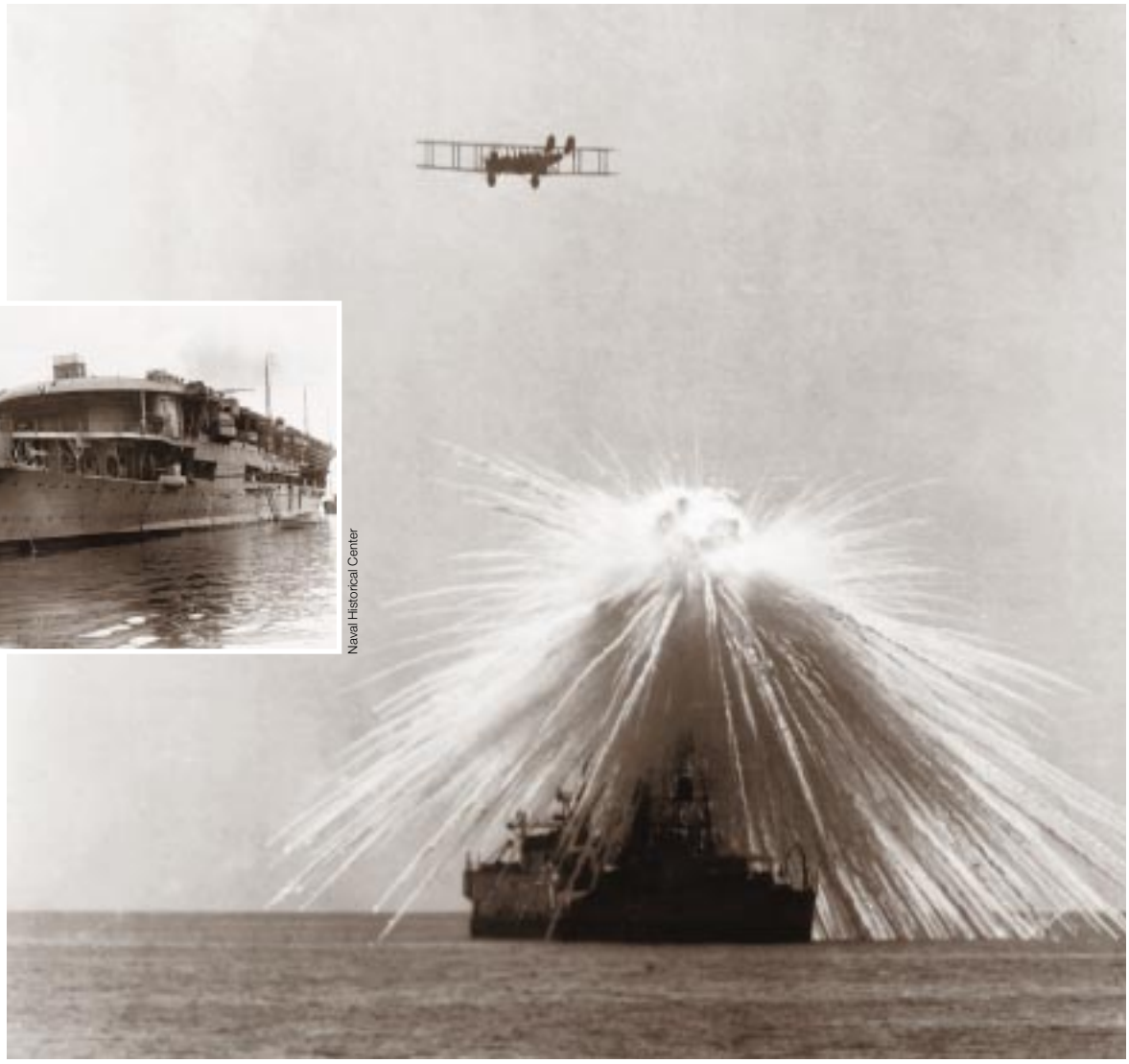
Naval Historical Center

Japanese cruiser *Tsugaru* being bombed in experimental attack (photo obtained by Billy Mitchell during foreign inspection, 1924).

Naval Historical Center

What was it like to be a senior officer then, with responsibility for evaluating new concepts that might supplant or change the paradigm in which he had served? There would appear to be two types of senior officers whose views mattered in different ways. The first were those serving in key billets but who would not reach flag rank. They knew they would not participate in the next paradigm so they had less incentive to get involved. Moreover, having done well in comparison to their peers, seeing the paradigm under which they served slowly becoming less relevant was hard to accept on a personal level and may have led to a certain skepticism. But though they continued to serve, they still influenced fellow officers and the flags under whom they worked and were a source of resistance to change.

Then there are those who continued to serve as senior captains or flag officers. They had to make decisions on the future of the service and nature of combat. They faced a choice between continuing with proven systems and methods or shifting resources to new concepts which might have been promising but difficult to realize. The latter involved both opportunity cost and risk of failure. Such choices would seem particularly difficult in a time of budgetary constraint. One finds this kind of conundrum facing the General Board in the 1920s and 1930s as it weighed the value of battleships versus carrier aviation. So what enabled senior officers to make the choices they did about naval aviation in the 1920s?



Army "bombing" *USS Alabama* with white phosphorus, 1921.

Naval Historical Center

HMS Furious after conversion from light battlecruiser.

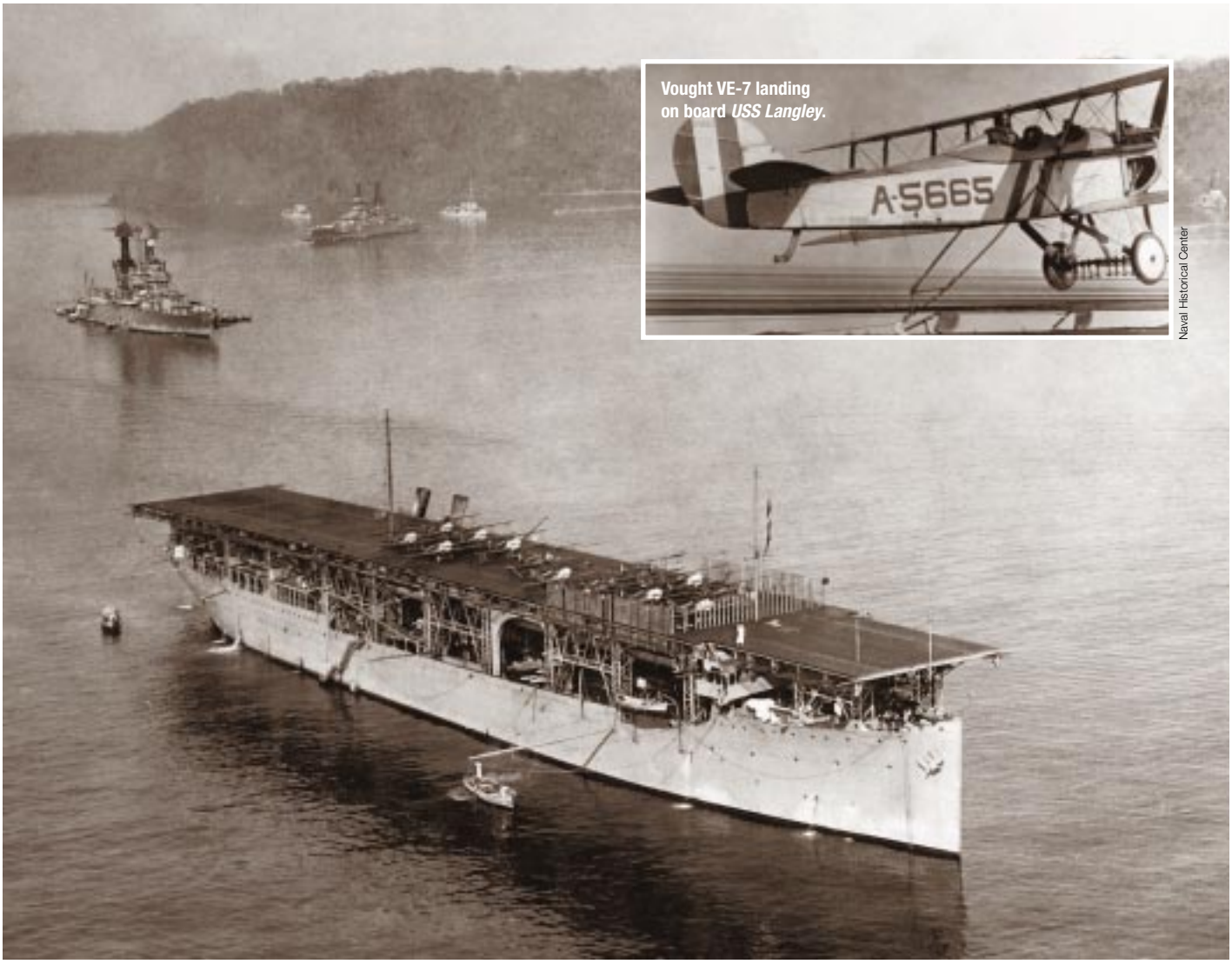
Naval Historical Center

The intellectual tradition of relying on an experimentalist approach to tactics and technology allowed for evaluating evidence in making operational and technical judgments. By implication, the feeling that serious ideas ought to get a hearing undoubtedly encouraged would-be innovators. As the potential of aviation increased, senior officers gave it their support.

The Royal Navy, by contrast, lacked an equivalent intellectual tradition. The British only established a naval staff shortly before the war and then at the insistence of civilian leaders. Staff colleges in Britain did not have the standing of the Naval War College during that period, nor were assignments to them desirable, whereas many future American flag officers attended and served on the staff at Newport. The Royal Navy was more hierarchical, with the putative presumption being that flag officers reached that rank because they knew the answers. In short, young and innovative would-be naval aviators had little reason for optimism regarding receptivity to their ideas.

Ideas for Carriers

Aircraft potential for spotting for battleships was noted very early by Britain and America. It addressed how to shoot accurately when spotting was no longer possible from the shooting ship (using other ships has the drawback of exposing them to enemy fire). The value of scouting from the air was underlined by its absence at Jutland and presence (zeppelins) on subsequent occasions which enabled the German fleet to avoid battle with the Royal Navy.



***USS Langley*, 1923.**

Other uses for aircraft were driven by specific tactical problems. Rifles then machine guns were mounted in friendly aircraft to stop enemy aircraft from doing reconnaissance in 1914. Air-dropped torpedoes were used to reach anchored enemy ships when the Dardanelles were blocked to friendly ships in 1915. Zeppelins and seaplanes found the enemy battle fleet at sea in 1916. Submarine and airship bases were bombed a year later. Targets too distant for land-based forces were attacked from the sea in 1918. All these ideas were tried in World War I combat.

Lieutenant Commander Henry Mustin came up with novel ideas for employing aircraft on his own. While commanding the flight school at Pensacola (1915–17), he prepared a lecture on the "naval airplane." As a gunnery expert with service on battleships, he knew that devastating long-range gunfire, effectively controlled from aircraft, could win engagements in minutes. He started with the idea of light aircraft carried and launched from battleships, then moved to launching and recovering them with a special aircraft-carrying ship. Sometime before 1917 he advocated the use of aircraft to attack in support of friendly battleships. It is not clear why he made this leap, but he discussed such ideas with W.S. Sims and others. After war broke out Mustin responded to an appeal by the Secretary of the Navy for war-winning ideas by suggesting bombing of land targets from sea-based platforms. This and a similar proposal by Lieutenant Ken Whiting, assigned to Pensacola during Mustin's tenure, were endorsed by British and American planners in early 1918.

Naval Historical Center

Moffett (second from left), 1922.

In sum, many innovations appeared to be attempts to solve specific problems. There seems to have been a lot less of "Given technology X, what militarily useful things might we do with it?"

Grasping the Vision

How quickly did those who grasped the concept arrive at a clearly-defined vision? In the U.S. Navy, Mustin was describing carrier aircraft as landstrike and seastrike forces in 1915–17. By the early 1920s, Newport was gaming specific tactical questions, getting at physical realities and constraints. The president of the Naval War College, Admiral Sims, stressed the connection between gaming rules and actual data. This was facilitated through regular correspondence among faculty members and aviators and, following its establishment in 1921, the Bureau of Aeronautics.

because of treaty constraints, there were not enough carriers for experimentation

The games suggested things like the pulsed nature of carrier striking power, the importance of many aircraft in the air, the need to strike first, and carrier air hitting an enemy carrier as the leading objective. Game outcomes had concrete results. By 1923 there were explicit connections between gamed ideas and design of both fleet exercises and warships. Similarly, lessons from the exercises and technical information on ships and aircraft were fed into game design and rules.

Outside the Navy, political pressures generated by airpower purists such as Billy Mitchell and his congressional supporters pushed the Navy to put ideas into at-sea operational capabilities by the mid-1920s. The prolonged and highly public battleship versus airplane controversy had the salutary effect of highlighting the question of the proper role of naval aviation.

In 1925, Admiral Moffett reassigned Captain Reeves, then head of the tactics department at Newport, as commanding officer of the experimental carrier *USS Langley* to test his ideas, many of which stemmed from games. Reeves, having determined through wargaming that the number of aircraft aloft was the key measure of striking power, solved practical problems associated with launching and landing more planes. As a result, *USS Langley* was deemed an operational unit by 1926. The presence of *USS Lexington* and *USS Saratoga* in fleet problems in 1929–31 suggested their utility and acceptance in a variety of roles, although not as independent strike weapons.

However, the mature concept envisioned carriers as an independent strike force against sea and land targets and was only achieved in 1944 after years of trial and error. Interestingly, after the fleet problems noted above, little work was done on employing larger numbers of carriers or what their role would be vis-à-vis the fleet. Because of treaty constraints, there were not enough carriers for experimentation. But there is also no record of work/gaming at Newport in the 1930s on such matters. This is puzzling given that Reeves became Commander in Chief, U.S. Fleet, in the mid-1930s and was presumably in a position to have such simulation and exercising done.

In the British case, the vision died early when those naval aviators who experimented with operations entailed in carrier strike warfare, albeit in primitive form, were transferred en masse to the Royal Air Force where success demanded adherence to strategic bombing.

Those who remained in the navy were by all accounts also "air-minded." However, their concept was wedded to bringing about battle with an enemy fleet, then combining air spotters with advanced long-range gunnery to kill ships. Based on wartime experience it was clear what aircraft were expected to do, and much of British naval aviation was dedicated to those ends. The clarity of that vision was such that there was little room to question it. The British experience suggests that overconfidence in operational concepts can blind an organization to better alternatives.

Individuals or Groups?

The relationships between individuals in their institutional settings is vital. The presidency of the Naval War College, the post of chief of the Bureau of Aeronautics, and the commodore's role as head of fleet aviation squadrons is what gave Sims, Moffett, and Reeves an arena to interact

Naval Historical Center

Bomber landing on *USS Lexington* during fleet problem, 1929.

professionally. By contrast the removal of the aircraft component of naval aviation from direct Royal Navy control in 1919 precluded appropriate players from conducting planning and designing experiments and exercises essential to developing the carrier concept. But there may be more to it. It is rather like the dispute between the "great man" and "impersonal forces" schools of history. Both individuals and organizations are crucial at different times and in different ways.

The creative spark necessarily comes from individuals or from interactions between them. Mustin appeared to be the first officer to see carriers as strike weapons. He actively discussed it with officers who later occupied positions where such ideas could be explored. The institutional setting mattered. This suggests that officers assigned to influential positions should be perceived as receptive to innovative people.

An individual may matter in other ways. The longevity of a senior officer in a key billet sometimes appeared crucial. Moffett remained the chief of the Bureau of Aeronautics from 1921 until his death in 1933. His incumbency gave him credibility with individuals and organizations closely involved with developing naval aviation, such as the General Board, Congress, and senior Navy leaders. This also enabled him to protect innovators such as Reeves from interference and influence the advancement of junior officers. It may have saved good ideas from being aborted in case of early failure. While such longevity has risks, its virtual absence today because of rapid billet changes may contribute to a lack of commitment to programs, inability to take the long view, and incapacity to build credibility for the bureaucratic struggle to get visions implemented.

Institutions played significant roles as well, particularly in seeing to the incremental details vital to translating ideas into practical reality. Organizations like the Bureau of Aeronautics and

Naval Historical Center

T4M–1 torpedo bomber on deck of *USS Lexington.*

the Naval War College were key. The role of the latter was important in two ways. First, long before carriers and real aircraft emerged, innovators like Mahan and Luce established intellectual rigor at Newport which was maintained into the 1930s. There was a reliance on rules of evidence with the proper questions asked, exercises done, and results weighed which made it credible to examine key questions with simulation in the 1920s. Second, iterative gaming at the Naval War College provided the theoretical underpinnings for tests by Reeves with early carriers, inputs into exercise and scenario design, and contributions to ship and aircraft design. In short, creative individuals also needed the right sandbox to play in.

The role of the Bureau of Aeronautics in providing data for Naval War College simulations and a home for aviation and aviators was also a factor. The bureau's interaction with nonmilitary institutions was key. It provided financial support for industry and initiated research in areas such as radial engines and served as a conduit for incorporating commercial advances to meet military needs, which was particularly critical as they outstripped military developments (like C^4I today).

The General Board played a significant role in integrating technology and tactics. Through it, voting on such issues as the future of aviation was carried out in a community of professionals, not all aviators, with a shared sense of what mattered. Any large organization should have some mechanism through which new concepts which are proved worthwhile become institutionalized.

Again, the British case is instructive for what was lacking. The Royal Navy had no senior champions along the lines of Moffett, Sims, and Reeves since those who might have assumed such roles now wore air force blue. It had no organizational mechanisms for relating technical choices with operational capabilities, a striking failure that accounts for much of the stunted development. Neither did it have, in the absence of acceptable platforms and aircraft, institutional mechanisms to examine alternative concepts as did the Naval War College.

Overcoming Barriers

Various barriers faced the U.S. Navy. Those confronted by Britain are of interest as well, if only to contrast the effect of America having avoided them, not always by intention.

Budgetary constraints. While significant, the effect of budgetary constraints was indirect. Certainly there were not funds for large numbers of expensive platforms to experiment with, but many would-be experiments could be primitively simulated through iterative gaming. The Bureau of Aeronautics was established to control funding which gave it the freedom to dedicate money to develop engine starters, arresting gear, better engines, etc., which incrementally solved many of the small technical problems. This also meant that such items were not hostage to yearly budgetary tradeoffs, ensuring continuity in development and easing a barrier to entry in contrast to many R&D efforts today.

Possible effects of the absence of budgetary constraints have been noted. Had the incipient rivalry between the U.S. Navy and Royal Navy continued unconstrained by treaty, spending on battleships might have crowded out spending for carriers and carrier aircraft.

Scarce funds ensured that Britain would be stuck with carriers built before requirements for sustained carrier operations were understood. The Royal Air Force focus on strategic bombing, coupled with control of all aviation assets, slowed British naval aviation development since aircraft acquisition was a zero-sum game. It precluded experimentation and may have lessened pressure to increase carrier aircraft capacity since the navy had little chance of getting more aircraft. The Royal Air Force consistently opposed increasing carrier capacity for just that reason.

Treaty constraints. Some have argued that the Washington naval treaties limited advances in carriers, particularly multi-carrier operations. But it appears that *USS Langley*, *USS Lexington*, and *USS Saratoga* would not have been built faster without treaties. Yet key developmental work was done on them and was directly reflected in the design of the *USS Essex* class carriers. By the time more carriers became available in the late 1930s,

USS Saratoga.

Naval Historical Center

Naval Historical Center

***USS Ranger*, circa 1930s.**

the treaties were no longer in force. There is no compelling evidence that more carriers would have been built in the 1920s and 1930s absent the agreements, especially given the political climate against defense spending.

What kind of carriers might the U.S. Navy have bought had battle cruiser hulls not been available for conversion? Lacking treaties, *USS Lexington* and *USS Saratoga* would have been completed as battle cruisers. What kind of carriers America might have designed then is hard to know, but Britain had sent the design of its first built-for-purpose carrier to the United States in late 1917, and one may wonder if and why American designers would have departed significantly from the plans of the acknowledged world leaders.

bombs were not shipkillers and naval aircraft could not have carried them if they were

The Royal Navy, on the other hand, paid an immediate and lasting price for its four extant carriers. Given the inability to replace them for budgetary reasons, it was stuck with the physical limits built into them. Since that directly affected aircraft design, and in turn concepts of operation, the Royal Navy was effectively locked into learning the wrong lessons from the wrong ships.

Sunk costs. The effect of sunk costs sticking Britain with the wrong ships has been noted. The United States did not face that problem; but the 1927 Taylor Board recommended acquisition of five small carriers of the unsatisfactory *USS Ranger* design that might have put the U.S. Navy in that position. In the late 1930s, the General Board was aware of that problem regarding aircraft in a period of rapid technological progress and recommended against acquiring a large inventory.

Technical barriers. Even had the Royal Navy grasped the carrier strike vision, it is difficult to see how it would have overcome the technical obstacles, given the financial inability to rid itself of the "wrong" ships and aircraft. Admiral Reeves solved a key technical problem for the Navy onboard *USS Langley* and thus paved the way for acceptance of carriers as fleet units.

The principal technical barrier to going beyond that to the wider conception of carriers as an independent strike force was aircraft and ordnance performance. In the 1920s bombs were not shipkillers and naval aircraft could not have carried them if they were. Torpedoes were shipkillers, but it was almost suicidal to attack antiaircraft equipped ships given the flight profile required. Until aircraft and ordnance that could kill ships were developed, it was difficult to sell the mature carrier concept, which was one reason battleships continued to have pride of place into the 1940s.

The risk of being wrong. In the early 1920s the General Board observed almost plaintively that

"it would be the height of unwisdom for any nation possessing sea power to pin its faith and change its practice upon mere theories as to the future development of new and untried weapons." The burden of proof lies heavily on those who propose change. The current way ostensibly works well; the new way may not be better, and it may be worse. Moreover, a particular new way may not be the best alternative. And new ways often imply high costs.

The key to overcoming this barrier is data which demonstrates the practical superiority (that is, lowers risks) of the new way. Initially, such data must come from theoretical explorations, simulation, and where possible testing with extant systems. Incremental experimental gains reduce risk and make it reasonable to continue the process on an increasing scale until their practical effect and superiority became institutionally accepted. This was basically what the Naval War College-Bureau of Aeronautics-fleet operations exchange achieved for carrier aviation in the 1920s.

Inability to experiment. Failing to consider alternatives is a certain barrier to entry and was manifested in various ways by the Royal Navy and U.S. Navy. Examples included:

- Unwillingness to experiment, best characterized by "we already have the answers." To an extent, the Royal Navy as the leader in early carrier aviation was sometimes guilty of assuming that its way of operating was the correct one, its problems were faced by all competitors, etc.
- No platforms. Arguably this was what precluded developing multi-carrier operations before the outbreak of war. But there remains the key question of to what extent other means, such as simulation or analysis, can get around the need for actual platforms until further down the conceptual road. It is conceivable that the support of senior officers discussed above could have, and perhaps ought have, led to better ideas of what multi-carrier operations would be like. The Royal Air Force chokehold over naval aircraft prevented some experimental work that might have alerted the Royal Navy earlier to problems it would encounter in 1940.
- No means by which to evaluate. The U.S. Navy was able to evaluate operational and tactical concepts through an intellectual tradition among senior officers. The Royal Navy was unable to do the same in a rigorous manner.
- Training realism. Moffett consciously accepted a high rate of peacetime damage to naval aircraft to push the envelope. Similar approaches prevailed in the *Luftwaffe* and Japanese navy in the 1930s. Both tolerated a high level of training casualties and damage to see what really worked.
- Error tolerance. To the extent reasonable error is not tolerated, the willingness to experiment is reduced. The counter to this is largely the open experimentalist "trial and error" approach so much in evidence at Newport in the 1920s. (Its relative absence today, certainly vis-à-vis promotion and assignments, may be a factor in RMA-related progress.)

Competing organizations. The British and American cases contrast sharply. The Royal Air Force crimped naval aviation efforts from the start by removing aircraft and naval aviators from the control of the Royal Navy. The fortunate failure of corresponding efforts to establish a separate air service probably prevented similar distorted effects on U.S. and Japanese carrier development.

The impact of competing concepts must not be overlooked. The Mitchell campaign forced naval aviation proponents to demonstrate their case. Within naval aviation there was competition with the carrier idea as well; land-based naval aviation played a significant role in both the British and American navies during World War II.

Political and military interaction. The relationship between political and military leadership differed greatly in Britain and America, particularly access to political officials by military officers. Since the Royal Air Force controlled all aircraft in Britain, the Royal Navy effectively could only present its views and requirements to an often hostile Air Ministry. By contrast, the U.S. system afforded alternate ways of advancing ideas. Congress, by virtue of being outside the military but able to intervene decisively in its affairs (beyond the power of the purse), could push ideas, even against substantial military opposition. The press also circulated ideas on various occasions during the 1920s when Congress intervened substantively in carrier aviation development. While outside intervention may add chaos, it may also prevent good ideas from being prematurely stifled.

Costs. Change meant investing in both carriers and battleships. Aircraft and submarines presented greater technological opportunities for navies in the 1920s even as reduced tension meant reduced funding to develop alternatives. There was not money to buy enough carriers to show that battleships and battlecruisers were about to be superseded. At the same time the evidence of carrier superiority was not clear enough for navies to gamble on not buying battleships and other forces. So America and Japan invested in both carriers and battleships. In Britain, the need for carriers to support the battle force was clear. Moreover, the limited carrier aircraft capacity meant a greater number of carriers was required—if not actually purchased.

Rapid technological progress rendered aircraft obsolete in the late 1930s and raised the cost of change, which is why the General Board in 1937 was against high production levels of

Naval Historical Center

***USS Lexington* during fleet concentration off Maui, 1932.**

carrier aircraft. But this had to be considered against the number of aircraft required to conduct current operations, train new pilots, and keep unit costs acceptable.

Competition and Change

There is a distinction between an enemy and a rival. Were the United States not forced to consider how to fight Japan in the Pacific, the need to take aviation to sea might not have been so apparent. Royal Navy design considerations, even in the post-treaty 1930s, were also affected by where carriers would be used (such as armored flight decks to survive against land-based aircraft in the Mediterranean). However, it was rivalry with Britain in engineering and on the operational level that helped drive early U.S. carrier development. Indeed, so little was known of the specifics of Japanese carrier aviation that "orange" aviation was usually given the same characteristics as U.S. naval forces in wargames.

The distinction between strategic opponent and technical rival is interesting. Is China today a potential strategic foe or Japan a technical rival? Which stimulates more competition?

Although crucial, there was no competition in the sense of directly playing off Britain or Japan (save in the latter case to describe the sandbox). Rather, competition to develop commercial aviation played a notable role in military aviation and later in increasing production. While there was little spillover from the civil sector to the Navy during the introduction of carrier aviation in the 1920s, an active exchange occurred over time. The National Advisory Committee for Aeronautics promoted dual-use technology, including aerodynamic streamlining, supercharged piston engines, and internally pressurized engines, assisted by Army and Navy financial and engineering support. Because of restrictions imposed on service contracting, the commercial aviation industry often led the Army and Navy in adopting new technology. (This is an interesting parallel with what appears to be the case today in such

sectors as telecommunications, computers, and possibly satellites.)

There was much less stimulative effect from British industry. It arguably showed in the lower quality of its aircraft. Perhaps the only top quality British plane in 1940, the Spitfire, was more the product of an individual designer than a solidly based industry.

there was no clear enemy and there were strong indications of significant technological changes

The effect of competing organizations may warrant further study, especially since so many conditions today resemble those of the 1920s. There was no clear enemy to plan against and there were strong indications of significant technological changes to come, major budget constraints, and a bitter roles and missions debate brewing.

While being conscious of change was essential, there was no particular way of achieving it. The meaning of carrier aviation varied even among naval aviators. In the U.S. Navy what allowed leading players with conflicting views to cooperate was a shared commitment to deciding rationally, on the basis of experimentation. By contrast the Royal Air Force, repository of all post-1918 British aviation assets, did not have an ethos of experimentation. It could not afford to in that financially constrained environment since its whole existence depended on maintaining and selling its fixed vision of strategic bombing.

The lack of senior level involvement was striking in the Royal Navy. Without awareness at decisionmaking levels, new concepts may never take practical effect. That was the most pernicious effect of Royal Air Force control over aviation. Whereas the experience of the Royal Navy during World War I convinced many senior American admirals to support aviation, no relevant audience of any size remained in the Royal Navy.

Senior leaders extended consciousness to important external players. For example, Moffett urged prominent figures to talk to the President, gained influence with members of Congress, and appealed to the public through the press and support for popular films such as "Helldivers" (1931). This was in stark contrast to the situation in Britain where senior officers could not approach senior civilian officials and so had less opportunity to present their case.

The Naval War College played an important role in two ways. First, the Newport games convinced fairly senior officers like Reeves of the potential of carrier aviation, thus making allies in the Navy. Second, games posed relevant questions and provided data, thereby reducing the risk of embracing a new concept.

A last significant factor was accumulating a pool of junior officers who were enthusiastic over the concept in its formative years—when its full potential could not be actually demonstrated because of technological limitations (such as weak ordnance and engines) and fiscal limitations (too few platforms to experiment). They would become senior leaders when better technology allowed full realization of the concept.

According to Tom Hone, vision is twisting a familiar situation in one's mind and seeing it in a new light. It requires a thorough understanding of extant technology and ideas, their strengths and weaknesses, and their potential to solve problems. The way visionaries get visions may also affect what they do with them. Visionaries tend to fall into two groups. The first is comprised of what might be called the "unconstrained" visionaries who believe in their vision as an end in itself (Mitchell). The second is more realistic—aimed less at a visionary mission and more at a visionary approach to fulfilling an existing mission (Reeves).

The vision that is eventually fulfilled may not be the one that starts the process. Along the way other players become interested and start to participate in various ways, thereby changing the vision incrementally over time. There may be competing versions of *the* vision, which in this case may be reflected by the competing visions of diverse factions within the naval aviation community in the 1920s when not all aviators saw large carriers as the proper vision. This is likely to happen with our vision of the emerging revolution in military affairs. **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.