Wings of

Prewar Technica

Part 1

By Lee M. Pearson

The mythology of WW II aviation contains tales of aircraft that were designed and developed by an inspired contractor at a time of great peril and rushed into production and combat to meet a dire need. In contrast, the Navy fought WW II almost entirely with aircraft of designs that predated the outbreak of war. Only the Curtiss SC, a battleship and cruiser scout, was begun after December 1941. Two aircraft – the TBF/TBM and F6F – were initiated between September 1939 and December 1941; both were vitally important.

Three designs were more than 10 years old by 1945: the Curtiss SOC and Consolidated PBY initiated in 1933, and the SBD in 1934. Their age emphasizes that aircraft development was complex and time consuming. The Navy strove to obtain airplanes that best fit its needs. In doing so, its development processes were a mixture of astute analysis and skilled design leavened by trial and error, as it determined types of aircraft, characteristics for each, and the most useful designs and models.

Captain S. U. Ramsdell's articles in this series *(NANews*, Sep-Oct and Nov-Dec 89) pointed out that the Bureau of Aeronautics (BuAer) and its field activities provided the Navy with aircraft and aeronautical equipment. BuAer's Materiel Division, comparable to today's Naval Air Systems Command, was responsible for aircraft design, development, and production. Guidance on types and characteristics was provided by other BuAer divisions and the fleet. Key members of the Materiel Division staff had aviation experience back to WW I in developing the special technologies needed to take airplanes to sea. Professionally, the staff contained both line and engineering specialty officers – Aeronautical Engineering Duty Officers after 1935, before then, Naval Constructors and Engineers – and civilian engineers and draftsmen.

Experimentation was centered at the Naval Aircraft Factory (NAF), built during WW I at the Philadelphia Navy Yard, Pa. "Factory" became a misnomer during the Republican administrations of the twenties; however, NAF designed and built some experimental aircraft. Its developmental abilities increased as laboratory facilities were built up in such fields as metallurgy, structures, instruments, etc. In 1923, the Aeronautical Engine Laboratory was relocated at NAF from the Washington Navy Yard in D.C. In 1933, a naval flight surgeon was assigned to NAF, beginning a physiological laboratory. In 1937, the Ships Experimental Unit was transferred from NAS Norfolk, Va., where it had pioneered in developing arresting gear.

There were other major technological facilities. Navy wind tunnels were an adjunct to the model basin at the Washington Navy Yard; in 1936, construction of a new model basin with wind tunnels was begun at Carderock, Md., northwest of Washington, D.C. Navy flight testing was carried out at naval air stations, usually NAS Anacostia, also in D.C. At the close of WW I, aircraft radio development was handled by a radio laboratory at NAS Anacostia. When the Naval Research Laboratory (NRL) was established nearby in 1923, the radio laboratory became part of it. Ordnance installations were usually tested at the Naval Proving Ground, Dahlgren, Va.

The National Advisory Committee for Aeronautics (NACA), the forerunner of the National Aeronautics and Space Administration, was responsible for aeronautical research. It had been created by public law in 1914 to "supervise and direct the scientific study of the problems of flight with a view to their practical solution." Its governing committee included two Navy members from BuAer; in addition, Rear Admiral David W. Taylor,

Victory,

Development

F4F

who retired from the Navy after WW I, served as a public member until 1938. NACA's research laboratory, on the lower Chesapeake Bay, contained wind tunnels; a towing basin opened in 1931 and other special facilities. During the interwar period, NACA headquarters was in the Navy Department, convenient to BuAer.

This colocation facilitated exchange of views between the BuAer and NACA staffs and no doubt brought synergism to the technical expertise of both.

Two episodes from BuAer's early days illustrate some of the complexity in aircraft development. BuAer selected a new training plane on the basis of "fly before you buy" tests of three competing designs. Aviators at Pensacola, Fla., who would be responsible for its use, did the test flying. After BuAer purchased 50 Boeing NB airplanes based on their findings, they were found to be susceptible to flat spins and unsuited for inexperienced pilots. More effective control of aircraft design and testing was needed.

The DT-1, the Navy's first carrier-worthy torpedo plane, was at the other extreme. When it was developed, Commander Jerome C. Hunsaker was head of airplane design. He later recalled that Donald Douglas had shared his BuAer office for a week while he designed the DT; thus, Douglas talked to pilots and engineers and considered their views in making the design. The down side, as Hunsaker pointed out, was that if the episode had become public, BuAer would have been vulnerable to charges of extreme favoritism. BuAer needed a better way of acquainting industry, on an across-the-board basis, with Navy thinking about airplanes.

BuAer, as part of the process of defining types of aircraft needed, was already using its drafting rooms to make design studies, including three-view drawings, performance calculations and, sometimes, wind tunnel data. After basic decisions were made, BuAer began sending the drawings and data to industry as part of informal design competition. Thus, the companies could either propose their own designs or develop an airplane based on the BuAer design. After they responded, BuAer evaluated their proposals, usually selected one or more for development, and issued contracts for complete design data and prototype airplanes.

In the late 1930s, BuAer stopped putting three-view drawings in the design competition package. Losers sometimes complained that they were not chosen because they had not slavishly followed the whims of BuAer's designers. Eliminating the drawings not only freed BuAer from that charge, but also eliminated any tendency among company designers to copy a BuAer design rather than use it as guidance in thinking creatively about the Navy's problems.

To obtain improved models of an existing design, a product improvement, or evolutionary, path was followed: new engine, changes to armament, improved structure, changes requested by squadrons, etc. For example, the 1934 XBT-1 (see "Naval Aircraft," *NANews*, Sep-Oct 89) through product improvement became the SBD that in

-5 and -6 configurations served as a firstline dive-bomber into 1944 and in less demanding roles for the duration. In contrast, the TBD-1, developed the same year, received only minimal improvements and was in production for only two years. Thus, it was outdated by December 1941 and was replaced in mid-1942 as soon as the vastly superior TBF became available. Product improvement was important in aircraft designs that remained in production over a period of years.

The remainder of this article will survey progress in some key areas: power plants, radio, shipboard equipment, and targets and guided missiles. It will conclude with a look at aircraft development of the four major WW II combat types: patrol planes, torpedo bombers, dive-bombers, and fighters. From this, I hope that the reader will gain appreciation of the manner in which the Navy utilized America's engineering and innovative skills on the eve of WW II.

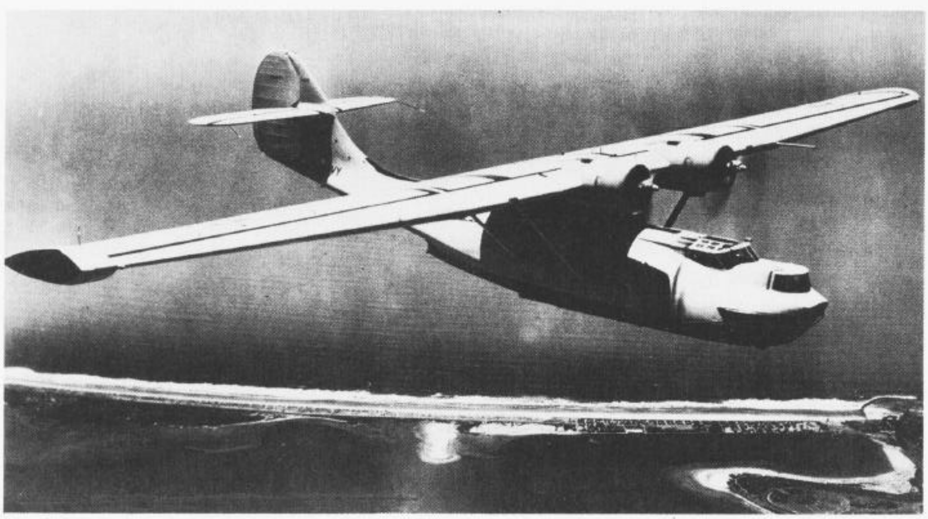
Power Plants

The airplane's engine is as important as its wing and is less appreciated. One pioneer airplane designer stressed this by asking me, "Who knows the name of Paul Revere's horse?"

Many fundamental changes affecting WW II engines were begun in the twenties and early thirties. **First**, the Navy decided to rely almost exclusively on radial, air-cooled engines beginning with the Lawrence 200-hp radial engine developed immediately after WW I. **Second**, in 1925, Pratt & Whitney Aircraft (P&W) became a rival to Wright Aeronautical Corporation which had taken over the Lawrence design. Subsequently, both firms competed in developing engines of about the same size and power. **Third**, about 1930 airplane designers began using circular engine cowlings, particularly the NACA cowling, to minimize the drag stemming from the radial engine's large frontal area. **Fourth**, designers of larger engines began arranging the cylinders in two rows to diminish frontal area. P&W began this in 1929; an experimental engine followed in 1931 with the R-1830 widely used during WW II. **Fifth**, use of radial engines necessitated that the Navy stress antiknock qualities in fuel. Navy squadrons, as early as 1926, began mixing tetraethyl lead with their gasoline while refueling.

An essential element of engine development was running an engine until it failed, redesigning the weakest part, and running it some more. The Aeronautical Engine Laboratory, along with other labs, engaged in such tests. Spark plugs, ignition wires, bearings, cooling fins, valves, cams, etc., were tested and improved. An emergency occurred in 1937 when new fighters and dive-bombers began experiencing failure of the main crankshaft bearing during high-speed dives. This problem, which threatened a generation of high-performance airplanes, was corrected by developing silver-lead-indium bearing material.

Overall during the interwar period, these various efforts resulted in a five-fold increase in engine power as well as greater fuel efficiency and longer engine life. At the close of WW I, most airplane engines were rated about 400 hp; by contrast the R-2800 and R-3350, both begun in 1936, were rated over 2,000 hp.


Concentrated prewar development of patrol seaplanes resulted in the PBY Catalina.

Radio and Radar

During WW II, no field was more crucial than radio and radar. A major step in improving radio performance in 1929 was a general shielding conference. Practical methods of shielding aircraft radio from stray electric currents were identified and shielding requirements were incorporated in the 1932 general airplane specification.

Navy engineers were deeply involved in studying high-frequency radio waves and developing high-frequency equipment. The GF-RU transmitter and receiver, the first effective radio for single-seat aircraft, was installed in fighters from the early thirties through WW II.

NRL developed the IFF Mark I aircraft identification system in 1935-37. The aircraft carrier *Ranger* tested it in 1938 and it went into service in 1939.

A rotating beacon homing system with sector identification was developed and tested in the same timeframe and replaced an earlier system in which airplanes were fitted with cumbersome loop antennas.

Beginning in 1936, the Bureau of Standards developed a radiosonde – a small radio transmitter attached to weather instruments – and a balloon for use in measuring and reporting pressure, temperature, and humidity at altitude and transmitting that information to a surface station. By the end of 1938, these were coming into use by ships and shore stations.

NRL's radar development began in 1930 after a stray aircraft reflected the radio signal during tests of a homing beacon. In 1934, the project was redirected from continuous waves to pulse. As experimental designs met their main objectives, a shipboard set was tested aboard the destroyer *Leary* in 1937. The XAF intended to operate aboard major ships was designed in 1938. Following its test onboard the battleship *New York*, Rear Admiral

Brewster's F2A Buffalo was inadequate to counter newer Japanese fighters at the war's outbreak.

Alfred W. Johnson, Commander of the Neutrality Patrol, described it as "one of the most important military developments since the advent of radio itself."

Ship-related Devices

Carriers and helicopters dominate modern Naval Aviation, but during the interwar years, many methods of taking airplanes to sea were investigated. Catapults for launching aircraft from battleships and cruisers were developed by the mid-twenties; in 1938, towed nets were devised that permitted these ships to recover floatplanes while under way. In 1926, an aircraft operated from a submarine and in 1940 from a destroyer. For lighter-than-air use, small aircraft, equipped with an overhead hook, flew from and returned to a trapeze on the Navy's last rigid airships; during WW II, Marines would experiment with a similar device, the Brodie gear, to operate a spotting plane from an LST (tank landing ship). An autogiro, with free-wheeling rotor, landed aboard the carrier *Langley* in 1931.

An interesting experiment was the bow arresting gear first installed on *Ranger* and tested in 1934. Bow gear was installed on the later prewar and early *Essex*-class carriers.

The earliest carrier catapults were designed to launch seaplanes, but a wheeled airplane was catapulted from *Langley* in 1929. Serious development of the flush-deck, compressed-air catapult was begun at NAF in 1934. Initially, these were installed on the flight deck and athwartships on the hangar deck of later prewar carriers. Hangar deck catapults were also originally planned for the *Essex*-class carriers.

BuAer hoped to increase flying boat loading by catapulting, and in the late 1930s, NAF began developing a 30-ton catapult so designed that two in parallel could launch a 60-ton flying boat. This was abandoned after a liquid rocket-assisted takeoff project was assigned in May 1941 to the Engineering Experimental Station at Annapolis, Md.

Patrol Planes

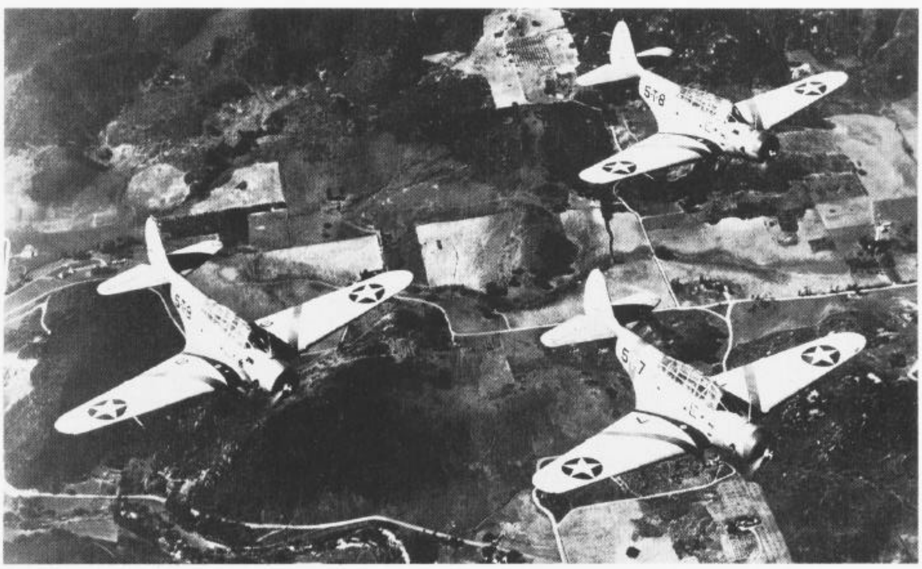
Today, the prewar emphasis upon flying boat patrol planes seems an anomaly. Through WW II, they played a major role. Before the war, the Navy operated water-based aircraft and left large landplanes to the Army. Any views to the contrary were lost in the brambly thicket of Army-Navy relationships. Moreover, the 1930s was the decade of the flying boat. A new era in research and development appeared imminent when the NACA opened its towing basin in 1931. Flying boats pioneered many transoceanic air routes. For example, in 1935, Pan American's *China Clipper* inaugurated San Francisco to Manila service.

Despite such promise, the 1933 PBY (originally designed as the XP3Y-1) – rather than a larger craft with longer range, higher speed, and greater carrying capacity – was the most widely used WW II patrol plane. The Navy sponsored at least six distinct flying boat designs as follow-ons to the PBY. A twin-float patrol torpedo bomber was at one extreme and the flying boat designed for catapulting was at the other. Major efforts went into more conventional large boats, some with two and others with four engines. Out of these efforts came the Martin PBM and the Consolidated PB2Y; both entered limited service in 1940. In late 1939, when the Navy needed to order a tested patrol plane for the Neutrality Patrol, the PBY had no competition.

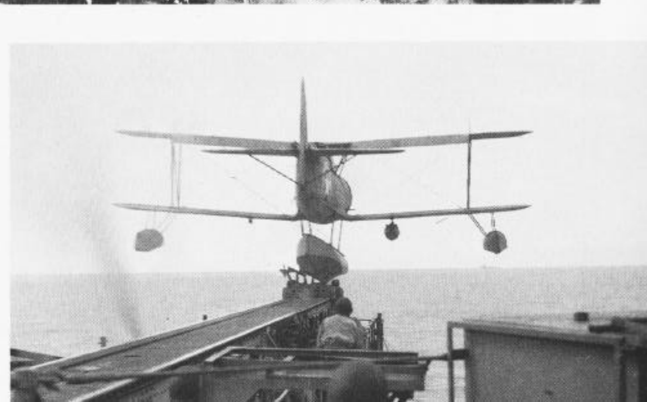
Dive-bombers and Fighters

Dive-bombing was developed by Navy fighter squadrons and shown to be effective against ships in 1926. Since a bomb sometimes struck the propeller or lodged in the landing gear of the releasing plane, the tactic was in jeopardy until 1931 when displacing gear, or bomb yoke, was developed which swung the bomb clear.

For several years, there was much overlapping among fighters, dive-bombers, and scouts. Some clarification took place in mid-decade; in 1934, BuAer held design competitions for both heavy (1,000-lb.) and light (500-lb.) dive-bombers and, in 1935, for a single-place fighter. Two aircraft were selected for development from each, and five of the six resulting designs were used at least briefly during WW II. The most important were the SBD dive-bomber and the F4F fighter.



Above, the TBD-1's minimal development before the war made it obsolete at the war's outset. Right, Curtiss SOC floatplanes served throughout the war. Facing page, aerodynamic refinements and a new power plant in the BT (XBT-1 shown here) eventually produced the successful SBD Dauntless.



The Douglas SBD was a product improvement development of the Northrop XBT-1. Northrop (in 1934, a subsidiary of Douglas) proposed one design as meeting requirements for both heavy and light dive-bombers. BuAer selected it for development as a heavy dive-bomber and procured it as the BT-1 (*NANews*, Sep-Oct 89). The last airplane was updated and designated XBT-2. By the time the BT-2 was ready for production, Douglas had absorbed its subsidiary and the plane became the SBD-1.

BuAer held another dive-bomber competition in 1938 from which it chose the Brewster XSB2A-1 and the Curtiss XSB2C-1. Development contracts were issued in the spring of 1939. The next year, after the fall of France, both were rushed into production before their first flights. With both, production problems compounded development problems. The SB2A was eventually used briefly as a training plane. The SB2C entered combat in November 1943 and served as the Navy's chief dive-bomber during the last year and a half of the war.

The 1935 fighter design competition winners were the Brewster XF2A-1 monoplane and the Grumman XF4F-1 biplane. Grumman decided its design was outmoded and in mid-1936 substituted the monoplane XF4F-2. During 1938 tests of these planes, the Navy was vying with the Army for the first 300-mph fighter and its new planes missed by about seven percent. NACA full-scale wind tunnel tests of the XF2A-1 provided a basis for cleaning it up so that it reached 300 mph. Tests of the XF4F-2 were equally successful. Full-scale wind tunnel tests were then used to improve many WW II aircraft. In mid-1938, BuAer chose to procure the F2A-1. Grumman redesigned the XF4F-2 into the XF4F-3, increasing wing area and installing a more powerful, two-stage, supercharged engine; the F4F-3 went into service in December 1940.

By 1937, fighter designers faced serious problems since multiengine bombers were approaching the speed of fighters. BuAer held fighter design competitions in both 1937 and 1938. The first, for twin-engine fighters only, was fruitless. From the next, BuAer chose to develop three widely different designs: the Bell XFL-1 with buried, liquid-cooled engine; Grumman XF5F-1 with twin, air-cooled engines; and Chance Vought XF4U-1 with a single R-2800 air-cooled engine and an inverted gull wing. Of the three designs resulting from the competition, the most conventional, the XF4U-1, came to meet expectations. According to Vought historians, it reached 400 mph on its first flight in May 1940. The Navy almost immediately placed a production contract.

Torpedo Bombers

There were only two design competitions for torpedo bombers during the thirties. One in 1934 produced the Douglas TBD-1 and one in 1939, the Grumman XTBF-1. The Navy obtained 130 TBDs and production was completed in 1939. The TBF, being four years younger and fitted with a more powerful engine, had much better performance. It also carried an additional gun, armor for the pilot and crew, and self-sealing fuel tanks.

Before the 1939 design competition, BuAer investigated glide bombing as an alternative to horizontal bombing. Elimination of the Norden bombsight would have saved space and weight but that was more than offset, in the eyes of BuAer engineers, by the fact that a stronger and therefore heavier plane would have been required. Unfortunately, there was no data on the relative accuracy of glide bombing and high-altitude horizontal bombing.

In conclusion, the foregoing touches many but by no means all of the areas in which the Navy improved aviation technology during the interwar years and adapted it to taking airplanes to sea. A few of the paths were deadends; others appear to have been so but more study would likely show that they had application in WW II. In some areas, such as rotary wing, it could be argued – but not proven – that greater prewar effort would have yielded more wartime utility. In retrospect, something should have been done with jet engines and much more with antisubmarine warfare.

Such carping should not be allowed to obscure basic facts. Overall, the Navy's efforts were successful. Airplanes that were developed and in production by late 1939 replaced earlier biplanes and fended off a thoroughly prepared enemy at the beginning of the war. With additions that were started between late 1939 and late 1941, they provided the wings of victory. ■

Lee Pearson was a naval historian from 1947 to 1977, when he retired from the Naval Air Systems Command.

See Part 2 in next issue.

50 Years Ago — WW II

November 1: Atlantic Squadron renamed Patrol Force, United States Fleet. Naval Air Station, Alameda, Calif., established.

November 15: Naval air operations began from Bermuda. First to operate were the planes of Patrol Squadron 54 based on *George E. Badger* (AVD-3).

November 16: The Bureau of Aeronautics established a catapult procurement program for *Essex*-class carriers. One flight deck catapult and one athwartships hangar deck catapult were to be installed on each of 11 carriers.

December 23: Naval Air Station, Key West, Fla., established.

December 30: The Bureau of Aeronautics directed that fleet aircraft be painted in nonspecular colors. Ship-based aircraft were to be light gray all over; patrol planes were to be light gray except for surfaces seen from above, which were to be blue-gray.