The Model 31 in flight near San Diego, spring 1941. Note high-aspect ratio Davis wing, sheet-metal outline of upper cupola turret. (AAHS negative 521)

THE CONSOLIDATED MODEL 31 / XP4Y-1 "CORREGIDOR" FLYING BOAT

by Chuck Hansen

One of the lesser-known (but still significant) products of the Consolidated Aircraft Corporation during the late 1930s was the Model 31, the first CAC aircraft to be fitted with the revolutionary new high-lift Davis wing. Originally conceived as a day and night transoceanic passenger plane, the Model 31 almost went to war as the XP4Y-1 *Corregidor*, and finished out its days as an engine and armament testbed for the U.S. Navy.

Design and Development—In 1937, Pan American World Airways invited aircraft manufacturers to submit designs for an advanced, long-range, passenger-carrying flying boat. The Consolidated Aircraft Corporation of San Diego, California, already a leading American company in the design and production of large seaplanes, came up with a proposal for a 52-passenger "boat" for either transatlantic or transpacific operation. Because the aircraft was to be designed and developed at Consolidated's own expense, it would have to be readily adaptable to both civilian and military purposes. This requirement would determine several design aspects relating to internal fuselage arrangements, and range and payload capabilities.

Design of the Model 31 was begun in July 1938 by a team led by the legendary I.M. "Mac" Laddon. The Model 31 was to break new ground in the development of modern flying boats—its engines, wing, hull, and retractable beaching gear were all new and untested. In order to save time and money, a new approach to the design, construction, and testing of the aircraft was to be followed, allowing the design team to conceive and implement their own ideas without any external interference from either Pan Am or the Bureau of Aeronautics of the U.S. Navy (a potential customer for the military version of the Model 31).

Probably the most revolutionary aspect of the design of the Model 31 was the so-called "Davis wing," a high-lift, low-drag, extremely efficient airfoil invented by David R. Davis, an aeronautical engineer who had been a former partner of Donald Douglas. The Davis "Fluid Foil" received U.S. Patent No. 1942688 on January 9, 1934. Because the Model 31 was to have better performance than both the earlier PBY and PB2Y military seaplanes, the behavior of the wing—in particular, the lift-to-

drag ratio—was extremely critical. Davis had developed a mathematical method of designing airfoils, a sharp departure from contemporary practices based largely on empirical design followed by extensive wind tunnel testing. Davis believed that a mathematically perfect airfoil section could be designed, and that its efficiency should approach or surpass that of the best airfoil yet developed by the National Advisory Committee for Aeronautics (NACA). Tests financed by Consolidated and conducted by the California Institute of Technology showed that Davis was right, and his new wing went onto the Model 31 (and later, on the B-24).

The new engines for the Model 31 were almost as advanced and unknown as the wing. In January 1936, the Wright Aeronautical Corporation, a division of the Curtiss-Wright Corporation, started development of a large, twin-row 18-cylinder radial engine, known as the R-3350. This 2000-horsepower powerplant was the successor to Wright's earlier twin-row effort, the R-2600, a 14-cylinder, 1500-horsepower engine. The R-3350 was the largest displacement radial aircraft engine under development in the U.S. in 1936, and its growing and teething pains would be many and prolonged for the next few years. The Model 31 would be one of the first aircraft to test these engines under actual flight conditions.

The hull (or fuselage) of the flying boat was also novel, in that it combined a relatively narrow planing bottom with a deep body. Several scale models of the hull were tested at a towing basin at NACA headquarters in Langley, Virginia, before the final design was selected. This unique hull was to cause several problems in the future when the boat entered its taxi and service tests. The fuselage was also made as aerodynamically "clean" as possible with flush skin riveting, and a sharply tapering, quickly rising afterbody carrying the empennage.

Stability on the water for takeoff and landing was to be provided by retractable underwing floats. The engineers at Consolidated first considered making these floats retract flush with the wingtips, as on the PBY and PB2Y, but Laddon's desire to maintain the integrity of the Davis wing—as well as its tapering tips—dictated that the floats would retract flush with the underside of the wing, halfway between the engines and the tips. The floats themselves, as well as the engine nacelles, were also influenced in their design by Davis' mathematical predictions.

Another new feature of the Model 31 was the employment of integral, hydraulically retractable tricycle beaching gear, consisting of a nosewheel and two outrigger wheels. The new Consolidated airplane was the first large flying boat to sport such equipment from its inception. Previous boats had to be positioned while still afloat over separate beaching gear, then winched ashore; the Model 31 could taxi right up a ramp under its own power. The beaching gear was rugged enough to be used as standard landing gear in an emergency, although at some risk of tire blowouts.

These were some of the aerodynamic, hydrodynamic, and structural considerations which entered into the design of the Model 31. The design and development process itself was perhaps as advanced, experimental, and unusual as the aircraft. Laddon's team believed that a great deal of time could be saved in building a new airplane if the builder were given a free hand in design, thus avoiding the many delays occasioned while awaiting customer approval on each feature. This requirement of customer agreement on a point-by-point basis was particularly

The Model 31 at San Diego, May 1939, showing mooring hatch in nose and original Hamilton Standard 15% '-diameter props.
(San Diego Aero-space Museum photo)

The Model 31 in its original configuration at the Consolidated factory in San Diego shortly *after* rollout in May 1939. Note the streamlined engine cowlings, straight fuselage spine. (San Diego Aero-space Museum photo)

The Model 31 in early April 1941. The straight spine has been replaced by an upward-swept afterbody, and a new mooring hatch has been added to the nose below the flight deck.
(Consolidated photo C31-133 via AAHS negative number 5512)

Another view in early April 1941, showing the outline of the proposed Consolidated tail turret, and the upper cupola blister turret.
(Consolidated photo C31-135 via AAHS negative number 5500)

The Model 31 as the XP4Y-1 in flight, summer 1943. Full military equipment has been installed, and the plane wears a two-color camouflage scheme. Note flared skirt on forebody of lower hull. (AAHS negative number 5513)

irksome on government contracts (i.e., for the Navy) wherein the aircraft manufacturer bore full responsibility for final weight and performance parameters, even though the design development was completely controlled and directed by the government. The result of this meddling (or supervision, depending on which side of the contract you stood) was that the development of the prototype of a large, multi-engine aircraft took between two and three years, and frequently resulted in an aircraft somewhat behind the state-of-the-art by the time it first flew.

Laddon also believed that construction could be speeded up by producing an essentially stripped, or "bare bones" prototype to determine flying characteristics prior to the installation of all structural, armament, and electronic equipment. The weight of such items could be simulated by properly placed ballast during flight tests. Postponing the installation of armament equipment, in particular, allowed for the latest (and best) weapons to be added after the design had been "debugged" and was ready for production.

In keeping with this full-speed-ahead design philosophy, the Navy was kept informed of progress on the Model 31, and the development of the prototype was not subject to the usual procurement routine. This exclusion of authority later led to some political problems (arising from the government's usual "not invented here" shortsightedness) which helped to doom the Model 31 as a warplane.

The benefit of Laddon's accelerated design process was immediately apparent: the time from design start to first flight was just 9 months and 25 days, a new record for the development and construction of a large airplane prototype (this record would be broken within a matter of months by the B-24 design team, which took only 9 months to build the first model—the B-24 benefited greatly from work on the wings and tail group of the Model 31, which were copied almost without change).

The chronology of the development of the Model 31 was as follows:

July 11, 1938—Authorization was given to proceed with the design and construction.

September 22—The keel was set up in a jig.

November 8—The wing center section assembly was started in the jig.

February 3, 1939—The center section was taken out of the jig.

February 25—The hull was sent to the final assembly department.

March 3—Outer wing panels were attached to the wing center section.

March 20—The complete wing was proof tested.

April 1—The complete wing was sent to the final assembly department, and attached to the hull.

April 29—Engine run-in tests completed.

May 5, 1939—The first flight test was made, approximately 44 weeks (ten months, less two days) from the date of go-ahead.

Description (Model 31)—As completed, the Model 31 was a twin-engine, high-wing cantilever monoplane flying boat. It featured an all-metal structure with flush-riveted, stressed-skin covering. The Davis wing included integral fuel tanks (with a capacity of 5400 gallons) in the center section. Hydraulically

The Boeing XPBB-1 taking off from Lake Washington, Seattle. This large, twin-engine patrol boat might have been a competitor to the P4Y for production contracts, had development of either aircraft ever reached that stage. (Boeing)

operated Fowler flaps extended from the ailerons inboard to the hull; tracks for the flaps were completely enclosed in the trailing edge of the wing, without external braces. Both flaps and ailerons were fabric-covered, as were the rudders and elevators on the twin-fin tail.

The hull was also all-metal, with one transverse step and one vertical knife-edge rear step. The hull structure consisted of transverse bulkheads and frames, and an aluminum-coated aluminum-alloy skin internally braced with longitudinal stiffeners. The depth of the hull was such that it accommodated two full decks, including a large flight deck and eight additional spacious compartments. As a commercial airliner, the Model 31 was to have had a maximum capacity of 52 passengers on a daylight run, and 28 passengers for night or sleeper operations (bunks were furnished for several passengers). For transatlantic flights the airplane was to have accommodations for 28 passengers.

The two Wright R-3350 Duplex-Cyclone engines furnished 4000 horsepower, sufficient to drive the aircraft to a top speed of 250 miles per hour, with a cruising speed of 160 mph (only 10 mph less than the *top* speed of the PBY!). The large fuel tanks afforded a range in excess of 3500 miles, as compared with the PBY's range of 2500 miles. The plane was originally fitted with two three-bladed, full-feathering, Hamilton Standard "Hydromatic" propellers.

As mentioned earlier, the beaching gear consisted of a dual-tired nose gear, swinging upward into the underside of the hull, and two rear outrigger wheels which retracted into wells inside the hull. The side wheels were removable as well as retractable, and the nose and side wheel wells were covered by doors when the gear was up. The outboard wing floats retracted to the undersides of the wing.

The aircraft had a span of 110 feet, a length of 73 feet, and a height (from ground to top of tail fin) of 23 feet (this would later change). The hull itself measured 15% feet from keel to upper surface. Empty weight was 25,000 lbs., and approximate gross weight was 50,000 lbs.

The Model 31 was rolled out of the San Diego plant on May 4, 1939- The next day, it was towed to the seaplane ramp and out onto San Diego bay. The first test pilot was chief Consolidated test pilot William B. Wheatly, who had first flown the XPB2Y-1, as well as many other Consolidated flying boats. Copilot for the first flight was George Newman.

The takeoff was quite smooth, the Model 31 using only several hundred yards for its run. In-flight performance was also very good; the aircraft was unusually maneuverable and fast. The only apparent problem was a tendency toward skipping on takeoff and landing, a rhythmical rising and falling of the hull in the water. This was caused to some extent by the narrow, long underbody of the fuselage (large seaplanes are invariably a compromise between good hydrodynamics and good aerodynamics —one always benefits at the expense of the other, and in the case of the Model 31, clean aerodynamics won out over a perfect hydrodynamic shape in the hull).

The XP4Y-1—Although the development of the Model 31 had been prompted in part by a request from Pan Am, and even though the Navy had not been invited to join in its creation, the aircraft was nonetheless designed and built with military purposes firmly in mind. Early flight test showed that the new plane was clearly superior to the PBY in several aspects: a higher

Head-on view taken August 18, 1943, at San Diego, showing extended wing floats, flaps, new Curtiss 16'-diameter props, and conventional beaching gear. Although it weighed only two-thirds as much as the PB2Y, the P4Y was almost as big in its exterior dimensions.
(National Archives 72-AC-66B-81/Consolidated C31-364)

The XP4Y-1 at San Diego, summer 1943. Compare with similar view of the Model 31 in April 1941 for differences in hull and equipment.
(National Archives 72-AC-66B-25/Consolidated C31-365)

The XP4Y-1 in August 1943. Both forward mooring hatches are open, and the wing float shown bears a white coloring, as opposed to the sea blue on the rest of the upper and side surfaces of the aircraft. (National Archives 72-AC-66B-1)

Rear right quarter view, summer 1943, showing tail turret. Compare with similar view taken April 1941. (National Archives 72-AC-66B-26/Consolidated C31-299)

Detail view of lower nose and left forebody of the hull, showing nose gunner's aiming window; flared skirt on hull; open bomb door, main entrance door, and flight deck escape hatch. The forward (nose) beaching gear is installed.
(National Archives 72-AC-66B-32/Consolidated C31-292)

View of left wing float retraction mechanism. The wing panel was hinged to the float so that float remained perpendicular to wing when retracted.
(National Archives 72-AC-66B-41/Consolidated)

ceiling, faster top and cruising speeds, longer range, and better armament provisions.

The aircraft was evaluated as a patrol bomber seaplane by a Navy Trial Board in 1939, and although the board rated its performance satisfactory at gross weights acceptable for an anti-submarine role, it was criticized for its poor hydrodynamic performance at high gross weight. There might have been an element of politics in the Navy's view of the Model 31 as well: having had no say in its development, they might have felt that it did not warrant serious evaluation, even though the plane clearly outperformed the PBY and the PBM.

The Navy's lack of interest did not prevent Consolidated from experimenting with modifications to the Model 31. A number of defensive armament installations were tested or proposed in 1940 and 1941. These originally consisted of those used on the larger PB2Y boat: a "birdcage" nose turret with a single .30 or ,50-caliber gun; waist window mounts; removable upper hatches for one or two guns; and a ' 'step' ' turret in the lower part of the upswept afterbody. Somewhat later, these mounts were modified: the nose and waist guns were deleted, and the upper fuselage mounts were replaced by a teardrop-shaped cupola blister just behind the wing atop the fuselage. The "step" turret was replaced by a Consolidated-designed twin .50-caliber tail turret (taken from the B-24); the empennage was raised slightly by a deepening of the afterbody, necessitated by the size of the tail turret. Photos taken in the spring of 1941 show both the upper cupola blister and the tail turret as sheet-metal mockups, suggested in outline only.

When the United States became involved in the war in the Pacific in December 1941, and the Navy faced the probability of the loss of most of its western island seaplane bases, the need for a fast, long-ranged seaplane arose anew. Two flying boats then under test came under scrutiny—the Boeing XPBB-1 *Sea Ranger,* and Consolidated's Model 31.

In a memorandum dated 17 February 1942, and signed by Cdr. R.E. Farnsworth, the Chief of the Navy's Bureau of Aeronautics approved procurement of the Model 31, and its conversion into a prototype patrol airplane. A new contract would be negotiated for the work of conversion, incorporating the latest design of the Wright R-3350 engines, armament, and other features to be agreed upon. The aircraft was tentatively designated the *Corregidor,* in keeping with Consolidated's contemporary practice of naming its flying boats after islands whose names began with the letter "C".

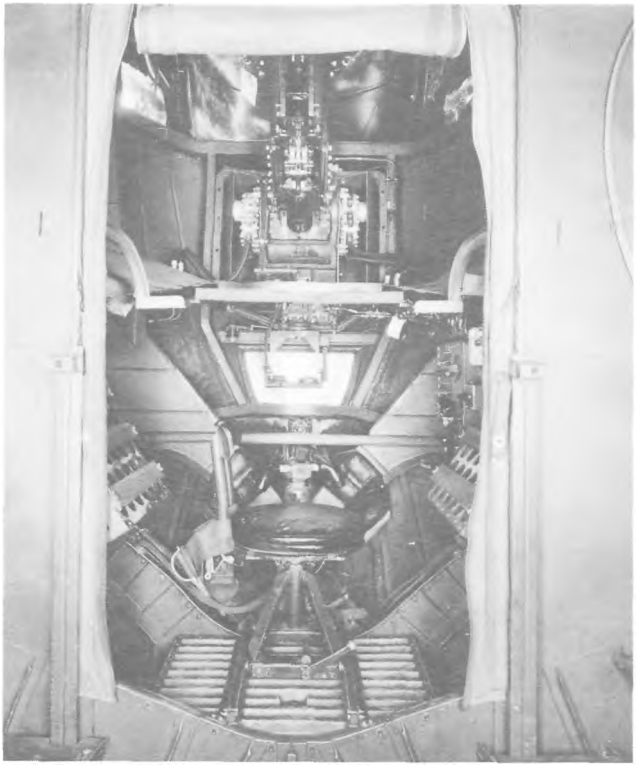
By mid-1941 development of the R-3350 engine was fairly far along. The main problem with it at that time was backfiring caused by poor mixing of fuel and air in the engine; these backfires occasionally led to the ignition of fires in structures surrounding the engine. This trouble was eliminated by the introduction of fuel injection systems on later R-3350s.

An attempt to solve the Model 31's most pressing problem—its poor hydrodynamics—was made with the addition of a flared "skirt" on the hull bottom, running a little over half of the length of the forward planing surface. This skirt slightly increased the beam of the forebody, as well as introducing an element of hydroplaning on takeoffs and landings.

Updated offensive and defensive armament equipment was installed, and by June 1943 the aircraft was ready for further testing by the Navy.

Description (XP4Y-1)—There were a few obvious differences between the external appearances of the early Model 31 and the XP4Y-1. Chief among them was the replacement of the arrow-straight spine of the hull by a gracefully upswept afterbody, paralleling the curvature of the lower hull rising to the empennage. This redesign and deepening of the afterbody was necessitated by the emplacement of a twin .50-caliber tail turret to protect the aircraft from attack from the rear. Another readily obvious difference was the addition of the flared skirt around the forebody of the lower hull. The chines of this skirt extended several inches out from the slab sides of the rest of the hull.

There were also a few other, less-significant changes: new cowlings around the engines; 16'-diameter propellers in place of the earlier 15'A'-diameter props; a fiberglass nose radome, above a new cannon mount; and addition of auxiliary entrance and mooring hatches in the nose section. To save weight, the retractable tricycle beaching gear had been deleted, and replaced



Exterior right nose view, showing radome, cannon, radio antennae masts, and flared forebody skirt. (National Archives 72-AC-66B-24/Consolidated C31 -300)

Looking into nose gunner's compartment from the anchor and mooring compartment. The gunner's swivel seat, elbow rests, cannon controls and sighting window are visible, as is the 37mm cannon itself, and a pair of ammo racks. Radome area is over cannon breech, and a bomb arming/control panel is to the right of the gunner's seat. (National Archives 72-AC-66B-58)

by more conventional beaching gear used on other large seaplanes. The width of the horizontal stabilizer had increased by 4', from 22' to 26'; the overall length had reached 74'%" (to the tail turret face), and the height to the top of the vertical stabilizers had reached 26'5".

There were of course many internal changes. The airline passenger seats, bunks, and equipment originally intended for the Model 31 had never been installed, in keeping with Mac Laddon's "bare bones" prototype philosophy. This arrangement made it quite a bit easier to install military equipment later on.

Entrance to the hull could be made through either of two auxiliary entrance hatches on either side of the fuselage in the lower nose compartment. Immediately forward of these hatches was the nose gunner's compartment.

The nose gunner—who also doubled as bombardier—controlled a single M-9 37mm cannon, for use as an offensive weapon against surfaced submarines. This gun could fire armor-piercing capped tracer, high-explosive tracer, or armor-piercing tracer rounds, weighing from 262 to 312 pounds per hundred rounds. These shells had a muzzle velocity ranging from 2600 to 3100 feet per second. One or two hits in a vital area of an enemy submarine might be enough to sink it, or at least prevent it from diving.

The 400-pound cannon was mounted on a hydraulic azimuth-elevation mount designed and built by the Ordnance Division of Bell Aircraft in Buffalo, New York. Designed by a pair of Bell engineers named John Trotter and LeRoy Maurer, it was awarded patent number 2,394,462 on February 5, 1946 (the original application was dated September 18, 1943). This cannon mount could be swung about 65° in elevation, and in a much smaller azimuth range. Shells were fed to the gun in 6-round clips by the gunner, who sat on a swivel chair below the gun, sighting through a window in the nose, and controlling the cannon via. a pair of handgrips. Racks for 16 clips were on either side of the gunner's seat; a rate-of-fire of 140 shells per minute could be maintained. (This same Bell 37mm cannon mount was featured as an alternate nose assembly on the Lockheed XP2V-1 mockup.)

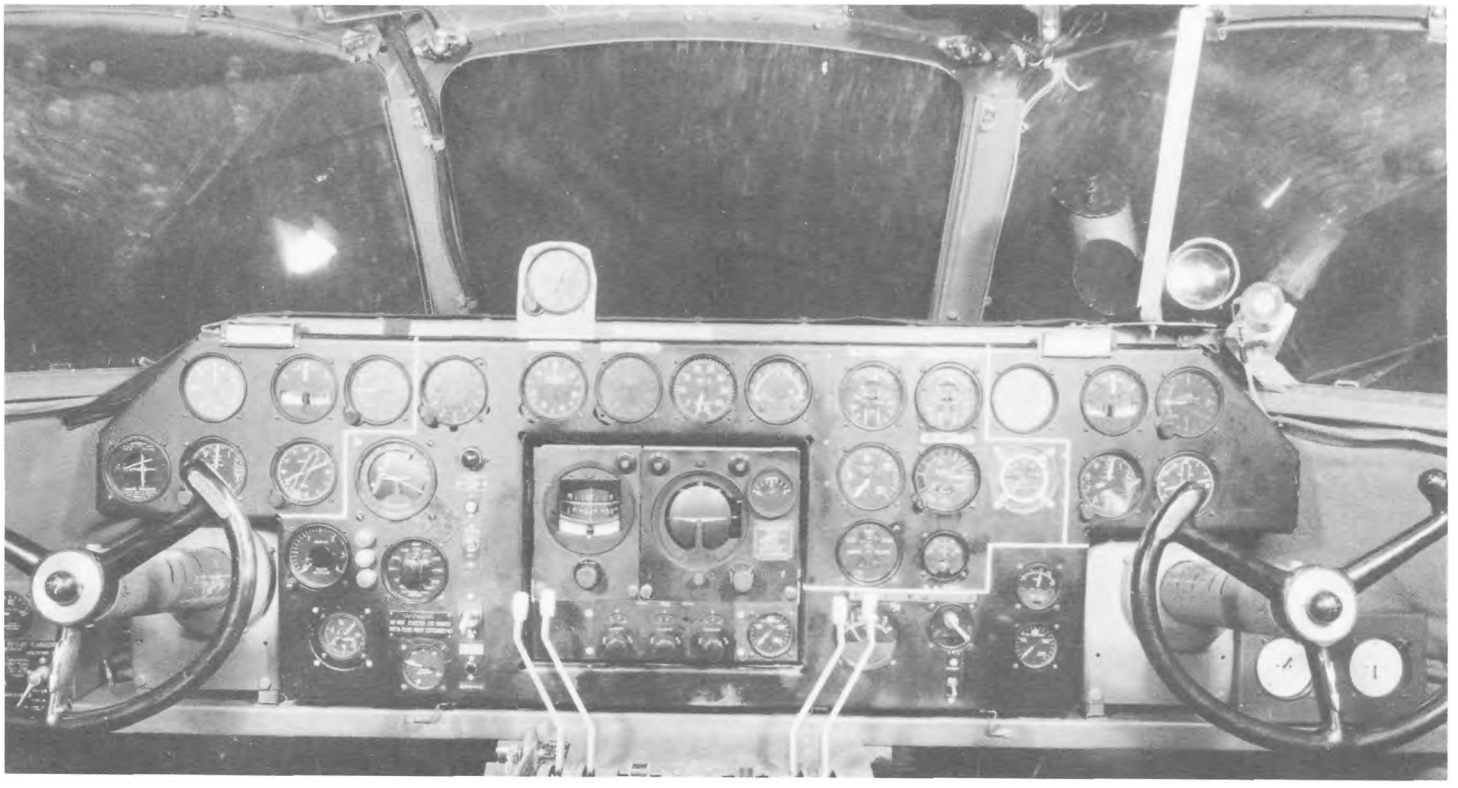
Directly over the gun mount, forward of the flight deck, was the fiberglass bulge for the ASG search radar which was to have been installed (it never was). A set of switches controlling the arming and dropping of the plane's bomb load was situated to right of the gunner's seat in this compartment.

The nose compartment was sealed off from the entrance door area by a zippered canvas flap. Aft of this was the anchor and mooring compartment, with the auxiliary entrance and mooring doors mentioned earlier. A Stewart-Warner auxiliary heating unit, capable of producing 100,000 BTUs, was on the starboard side of this compartment, slightly aft of the mooring hatch.

Immediately aft of the anchor compartment, and below the flight deck, was the crew's rest quarters, containing four bunks, a clothes locker, galley equipment, water storage, and a sea water distiller. These quarters were intended to be used by off-duty crew members during long flights.

The flight deck occupied the area directly over the anchor compartment and the crew's quarters. There were stations for four men: pilot, copilot, navigator, and flight engineer-radio operator. The pilot and copilot sat at the front of the flight deck; a full set of flight instruments was provided for each. Push-pull control wheels and sliding rudder pedals as used on the B-24 were provided; a control pedestal for flaps, floats, engines, lights, fuel, and trim tabs was located between the seats. Heating and radio controls were in an overhead switch panel. Each flight officer's seat was adjustable and fully cushioned.

The navigator's table and seat were located directly behind the pilot; his equipment included all the necessary compasses, weather instruments, and flight instruments. Directly aft of the navigator's table, on the port side of the flight deck, was an emergency escape hatch (the overhead astrograph dome was built into another escape hatch). The flight engineer-radio



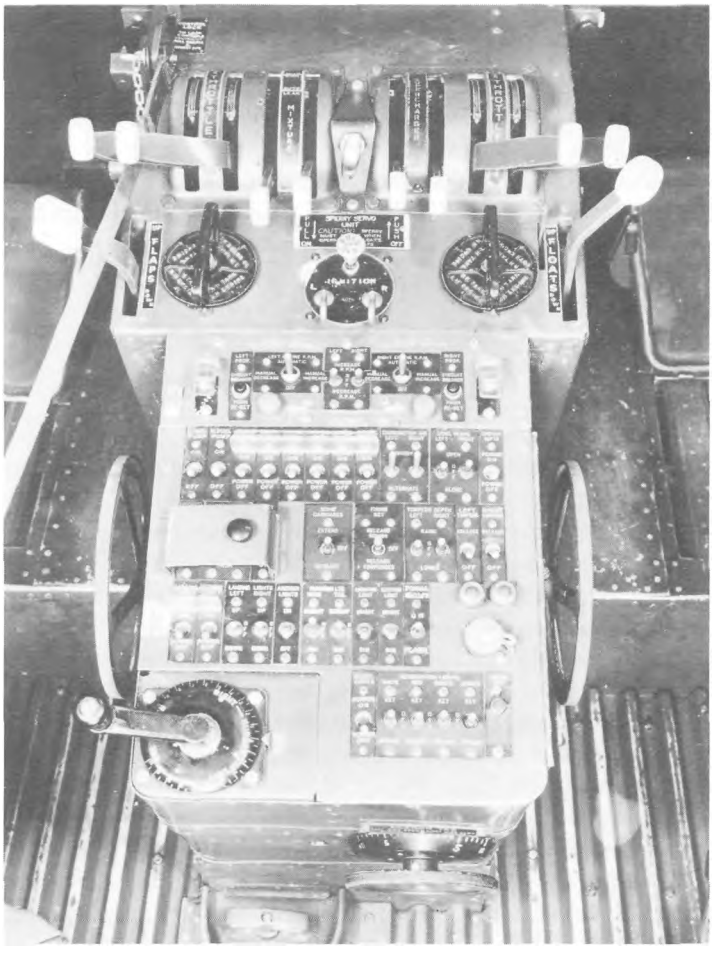
Main instrument panel in XP4Y-1 cockpit, showing flight, engine, and navigation instruments, as well as rudder pedals and control wheels. (National Archives 72-AC-66B-53/Consolidated C31-311)

operator sat on the starboard side of the flight deck, behind the copilot's station. His equipment included a full set of radios, and an automatic encryption/decryption device to encode and decode messages. All flight stations were provided with armor protection and soundproofing; the forward windshield was equipped with a thermal anti-icing system which pumped heated air between the double panes.

Aft of the flight deck was the depth bomb compartment. An armored door and a short ladder led into this compartment, which contained the airplane's main offensive weapons load. Alternate groups of eight 325-lb. depth charges, or four 650-lb. depth charges, or four 1,000-lb. mines could be carried internally (a pair of torpedoes could be carried externally under the wings). The main wing spar, and center section fuel tank, carried through this compartment, overhead from port to starboard.

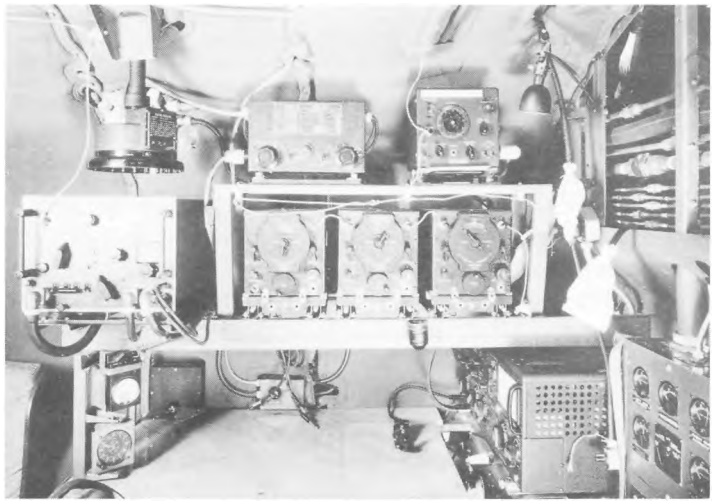
During the refit of the Model 31 to military condition, thought had been given to carrying the bomb load in cells in the wing, or on fittings below the wing (bomb doors in the hull were ruled out, and the engine nacelles were not deep enough or long enough to provide carrying space). In order to minimize drag, and (once again) to maintain the integrity of the Davis wing, the Consolidated engineers decided to mount the bombs on cars or carriages running on tracks from the interior of the hull to the undersurface of the wing inboard of the engine nacelles, as was done on the Short Sunderland flying boats in England. These electrically operated carriages would remain in position under the wings until the bombs were dropped, and then retract inside the hull. The flush-fitting bomb hatch doors were included as an integral part of the carriages. Since only four bombs could be carried at a time on the cars, any additional weapon loads had to be loaded by hand (via cranks and pulleys) onto the carriages (the additional weapons were stored in racks below the bomb carts).

Also in this compartment were an auxiliary hydraulic standby



Control pedestal between pilot's and copilot's seat in the cockpit. This unit contained controls for flaps, floats, propellers, throttles, ignition, lights, trim tabs, fuel tank selection, mixture, and superchargers. The strap running alongside the pilot's seat connects to the control lock, and is there to remind him to unlock the controls before takeoff. (National Archives 72-AC-66B-51)

Part of the radio operator's station behind the copilot's seat on the flight deck. The table shown was to have carried the plane's radar controls and display when the ASG air-to-surface search radar was installed. Here it carries (locked) flight test recording instruments from the National Advisory Committee for Aeronautics (NACA). (National Archives 72-AC-66B-47/Consolidated 031-316)



The radio operator's table and radio transmit/receive and direction-finding equipment, at the rear of the flight deck on the starboard side behind the copilot's station. (National Archives 72-AC-66B-46/Consolidated C31 -317)

The navigator's table on the port side of the flight deck aft of the pilot's station; most of the equipment shown in this view is display and recording apparatuses for flight testing. An emergency escape hatch was located on this side of the flight deck, between the navigator's table and the rear bulkhead.
(National Archives 72-AC-66B-44/Consolidated C31-319)

pump; fuel flow controls, with crossover valves; and a manual emergency release system for the depth bombs.

Aft of the bomb compartment was the waist turret section, featuring the main entrance door to port, and an auxiliary power plant and bomb hoist to starboard, as well as a beaching gear hatch. A removable ladder provided access to the upper part of the bomb compartment on the port side. Aft of the port entrance door was another ladder, leading up to the main work platform and mid-upper (waist) turret. A large escape hatch was over this platform, which carried a large emergency life raft and provisions.

The waist turret was an ERCO 25OSH-1 twin .50-caliber gun turret, first designed for use on the XPBB-1 (and later used on the PB4Y-1 and PB4Y-2). About 2000 ERCO 25OSH turrets (including the -1, -2, -2A, -3, and -3A models) were produced between 1940 and 1945, at a peak rate of about 200 per month in 1944. The Engineering and Research Corporation (ERCO) had been the designer and builder of the revolutionary dual-control *Er coupe* aircraft before the war.

The turret ball was 54" in diameter, and weighed 561 lbs. empty, and 1,131 lbs. when loaded with a gunner and 1300 rounds of belted .50-caliber ammunition. The turret shell was suspended on trunnions, so that it could tilt backwards and forward about a horizontal axis. The trunnions were mounted on a horizontal bearing ring, and the turret and trunnions could revolve 360° to the left or right about a vertical axis. The two .50-caliber machine guns were fixed in the turret, so that the whole unit had to move to train or point the guns. The turret was driven by a self-contained, electro-hydraulic power unit, operating off the airplane's power supply.

The gunner entered the turret through a small curved and padded side-hinged door which formed the back of the gunner's seat when closed. Armor protection was provided in front of the gunner.

The hull afterbody rose steeply aft of the waist section, terminating in the tail turret, which was sealed off by another zippered canvas flap, as in the nose compartment. A chemical toilet, flame floats, and the APU (auxiliary power unit) oil tank were in the aft hull area, along with two flare chutes (port and starboard).

The tail gun emplacement was a United Shoe Machinery Corporation M-l twin .50-caliber hydraulic swivel gun mount. Before the war, USMC had been a builder of shoe repair and sewing machinery in Boston, Massachusetts; in the spring of 1941, it entered the field of airborne fire control equipment. USMC's main contribution to the war effort would be the design and manufacture of a hydraulically boosted, single .50-caliber gun mount for waist guns on PBM-5s, along with a number of M-l twin mounts installed on some B-17Es and Fs (other experimental USMC designs would include twin .50-caliber boosted waist gun mounts for the XB-40 and XB-41; pressurized upper and lower 37mm cannon turrets for the XB-36; and a quad .50-caliber tail gun mount for the XB-35).

The M-l mount consisted of a separate hydraulic power unit, an N-6 flexible gunsight and camera bracket, a support mount for the two guns, and a hand-operated control unit, with hand grips and safety/firing switches. The sight was coordinated with the guns by a mechanical linkage. The entire assembly weighed 145 lbs.; the guns had a 60° cone of fire in all directions to the rear of the plane. Armor plate and armor glass protected the

Port side bomb cart in ready position under left wing. The bomb door was an integral part of the cart. One torpedo (Mk. 13 Mod 1 or 2) could be carried below each wing, between the bomb cart tracks and the respective engine nacelle. The outline of the flight deck escape hatch is visible forward of the bomb door. (National Archives 72-AC-66B-34/Consolidated C31-309)

(National Archives 72-AC-66B-62)

Bomb compartment on XP4Y-1, aft of the flight deck (note ladder and door to cockpit). Eight (unarmed) AN Mk. 17 Mod 2 325 lb. depth bombs can be seen; four are on the bomb carts, and four others are in racks below the wing center section. An alternate load was four 650-lb. Mk. 29 depth bombs. Additional bombs had to be hand-fitted to the bomb carts after the first were dropped.

gunner from attack, and large ammo boxes were provided with a capacity of 1600 rounds. An overhead escape hatch offered a means of emergency egress.

Of the three experimental defensive armament installations on the XP4Y-1, only one, the ERCO turret, saw any large quantity production and combat use (the USMC mount received U.S. patent number 2,409,041 on October 8, 1946; the original application was dated May 12, 1942). The Bell nose cannon mount provided some new information on the practicability and utility of large-bore, high-velocity aircraft cannon, but it was never built into any other aircraft (aside from the XP2V-1 mockup). Some of USMC's M-l twin .50-caliber gun mounts did see action (on B-17s) in Europe, where they provided a marked improvement over the usual Bell-designed tail mounts on most B-17s.

The defensive armament arrangement on the XP4Y-1 was predicated on the assumption that any air-to-air combat would take place while the plane was in flight near the water, so no protection in the lower hemisphere (below the aircraft) was provided. The four .50-caliber guns would give nearly full fire coverage in the upper hemisphere (above the airplane), with concentrated fire from four guns to the rear. Beam coverage was not very good, as the guns in the mid-upper turret could not be depressed far enough to sweep much of the area alongside the aircraft.

Planning for Production—The Navy had decided in March 1942 to purchase the Model 31 and convert it into a patrol seaplane for antisubmarine use. Contract NO(s) 2551A for $433,000 was signed in April 1942, with a delivery date of July 1943 for the first aircraft (Consolidated had spent a million dollars of its own money developing the Model 31). Bureau of Aeronautics serial number BuNo 27852 would replace the Model 31's civil registration of NX21731.

Consolidated suggested in the spring of 1942 that the P4Y-1 be built alongside the B-24s being produced at Fort Worth, Texas; nearby Lake Worth would provide a convenient test basin and seaplane port. The Army Air Forces, under whose control production would fall, stated in June that any additional airplane manufacturing at Fort Worth would be impractical due to an acute shortage of labor and housing. As an alternative, P4Y-1 production was suggested at either the Consolidated plant in San Diego, or at the Boeing plant in Vancouver, British Columbia (where the PB2B-1, the Canadian version of the PBY, was being built for the RAF and the RCAF). Production of the P4Y-1 in Canada was contingent upon plans for the future of the XPBB-1, then undergoing Navy evaluation.

On October 29, 1942, the Navy authorized the procurement of 200 P4Y airplanes, to be produced at a rate building up to approximately 45 aircraft per month. To meet this ambitious production schedule, the government in January 1943 transferred to Consolidated a large airplane factory at Lake Pontchartrain, New Orleans. This facility was to have produced flying boats for Vought-Sikorsky; it would now instead serve as the center of P4Y manufacture.

The End of the Program—In September 1942, the Navy's Bureau of Aeronautics had conducted a "paper" study of the proposed performances of the XP4Y-1, the PBY-5, the PBM-3C, and the PBM-4. A comparison of operating characteristics and armament equipment had shown that the P4Y was superior in range, speed, rate of climb, and defensive armament to the PBY-5, and only inferior in defensive armament to the PBM models. Its overall performance qualities (at least, those promised by Consolidated prior to extensive flight testing) were rated as "superior." It seemed to be the long-sought replacement for the aging PBY boats.

The reworked prototype first flew in July 1943, and tests were

(National Archives 72-AC-66B-73/Consolidated C31-353)

In the waist turret section, amidships, looking aft and up to the main work platform and mid-upper turret. The main entrance door was on the port side of the hull at this point, with an auxiliary power unit to starboard. A large escape hatch is visible above the work platform at the top of the hull.

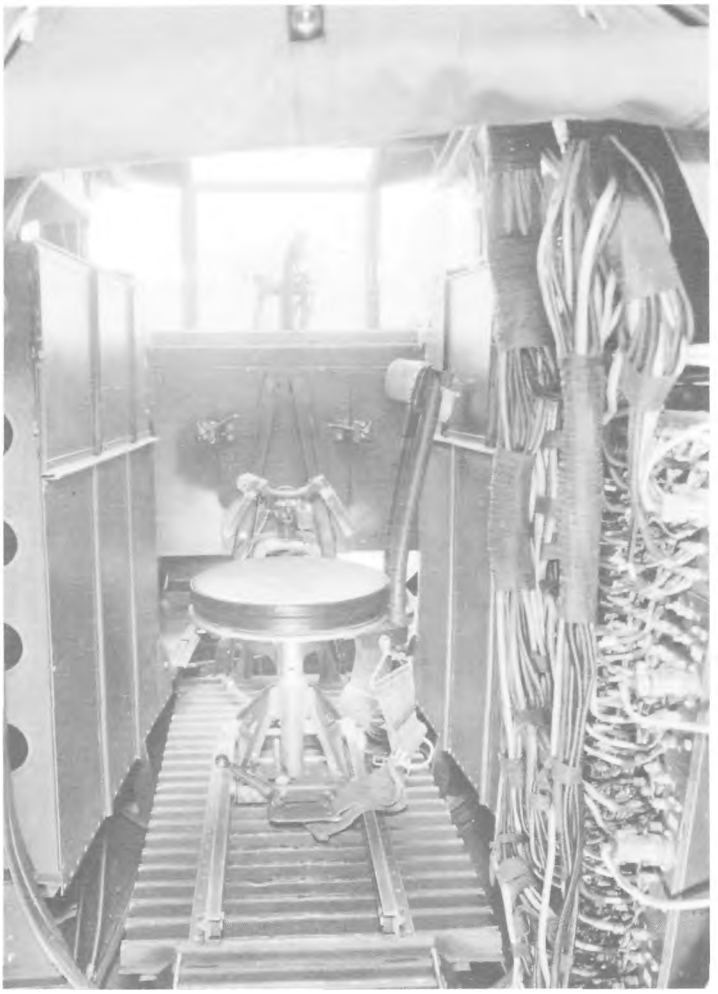
Exterior view of the ERCO 250SH mid-upper turret, looking aft from the escape hatch. The entire plexiglass top of the turret could be removed to provide an emergency escape route for the gunner.
(National Archives 72-AC-66B-11/Consolidated C31-281)

conducted soon thereafter by a Navy trial board. The hydrodynamic problems with the hull had been reduced in severity; Consolidated flight tests had shown a marked improvement. Unfortunately, there was still some skipping on landing at high gross weights, and the trial board concluded that the hull's hydrodynamic deficiencies could not be corrected without a complete redesign.

Another factor entering into the Navy's plans for the P4Y was the availability of Wright R-3350 engines. The Army was in the process of expanding its B-29 production, which would consume prodigious quantities of R-3350s, to the point that Wright's facilities would be sorely strained to meet the Army's demands. In addition, the R-3350 was also considered for use of the PBB-1, the JRM "Mars" transports, the B-32, and the C-69 *Constellation.* Given these demands upon Wright, priority could be assigned only to proven aircraft, or to those that were deemed absolutely necessary to the armed forces. Experimental types would have to wait their turn, or find other types of powerplants.

Given this shortage of engines, and the poor hydrodynamic qualities of its hull, the P4Y was doomed never to reach the production stage specified in October 1942. The New Orleans facility was put to work (starting in July 1943) on PBY construction, and continued in this role to the end of the war (the XPBB-1 suffered a nearly identical fate: in spite of its performance and expected utility, it too was canceled, and its factory in Renton, Washington, was turned over to B-29 manufacture).

Although the XP4Y-1 never reached full-scale production, and never saw combat duty, it was very valuable in providing an airframe to evaluate and develop the Davis wing, which was later grafted onto the B-24 and PB4Y-2 (and which also influenced the design of the wing for the B-32). In this sense, it acted as a prototype for a line of successful landplanes.



Interior view of tail turret, showing (open) zippered canvas closure, gunner's swivel seat, ammo boxes, and hand controls.
(National Archives 72-AC-66B-7/Consolidated C31-272)

PERFORMANCE CHARACTERISTICS
PBY-5, P4Y-1, PBM-3C and PBM-4

	PBY-5 Overload	P4Y-1 Normal	P4Y-1 Overload	PBM-3C Overload	PBM-4 Overload
Gross Weight	34000	46000	50000	56000	60000
Weight Empty	17413	28089	28089	32378	36784
Fuel Wt., 4 650-lb. Depth Charges	8868	11670	15460	12858	13260
Vmax @ S.L.	168	233	232	182	210
Vmax @ Critical Altitude	181/7500	250/13600	248/13600	196/13000	221/13600
Vstall with Power	78	89	92.7	76	77.4
Rate of Climb, Ft./Min.	480	1230	1060	310	700
Service Ceiling, Ft.	16700	21400	18600	14400	18600
Takeoff in calm, sec.	72	36	46	68	31
Range, 4 650-lb. Depth Charges	2700	3130	3930	2580	2420
Engines	2-R-1830-82	2-R-3350-8		2-R-2600-12	2-R-3350-8
Fuel Capacity, gal.	1478 Total	2727 Total		1750 Fixed	2360 Fixed
Gun Pointing	Manual	Power		Power	Power
Turrets—Bow (guns/cal./rds ammo)	1-30-1000	1-37mm-120		2-50-800	2-50-800
Top Waist (guns/cal./rds ammo)	—	2-50-2000		2-50-1200	2-50-1400
Side Waist (guns/cal./rds ammo)	1 -50-420	—		1 -50-420	1 -50-420
Side Waist (guns/cal./rds ammo)	1-50-420	—		1 -50-420	1 -50-420
Tunnel (guns/cal./rds ammo)	1 -30-500	—		—	—
Tail (guns/cal./rds ammo)	—	2-50-2000		2-50-2000	2-50-2000
Armor Weight	576	869		1178	1194
Bomb or Mine Capacity	4—1000 or 4—500 or 12—100	4—1000 or 2—1660		8—1000 or 8—500 or 12—100	8—1000 or 8—500 or 12—100
Depth Charge	4-650	8- -325 or 4—650		8—650 or 8—325	8—650 or 8—325
Torpedo	2—1935	2—2147		2—1935 or 2—2100	2—1935 or 2—2100

P4Y-1
Class VP Anti-Submarine Patrol Flying Boat
Estimated Performance Summary

		Patrol 8 325-lb. Depth Charges	Patrol 4 1000-lb. Mines	Torpedo 2 Mk. 13-2 Torpedoes	Overload Patrol 8 325-lb. Depth Charges
Fuel Load	(Gallons)	1,611	1,393	1,322	1,923
Gross Weight	Lbs.	46,000	46,000	46,000	48,000
High speed at sea level	MPH	236	236	223	235
High speed at 2,500 ft alt	MPH	242	242	230	241
High speed at max eng rated alt 13,600 ft	MPH	255	255	241	254
High speed at critical alt 13,600 ft	MPH	255	255	241	254
Stalling speed at sea level—full load (power)	MPH	86	86	87	88
Initial rate of climb at sea level ft/min	1,400	1,400	1,260	1,330	
Service ceiling (ft)		22,100	22,100	19,900	21,200
Maximum range	St Mi	2,500	2,150	1,950	3,000
Takeoff time	Sec	35	35	40	45
Power Plant	2-WAC-R3350-8 (two speed)				
BHP/RPM/Alt—Normal	2100/2400/SL-2500' 1800/2400/13,600'				
BHP/RPM—Takeoff	2300/2800				
Propeller	Curtiss 3-blade hollow steel 16' diameter				

Preparing for takeoff, summer 1943. The starboard beaching gear hatch is open (to release the gear), and the nose beaching gear is already on the ramp.
(National Archives 72-AC-66B-28/Consolidated C31-296)

P4Y-1
Class VP Anti-Submarine Patrol Flying Boat
Estimated Weight Summary

Weight Empty		28,262 lbs.
Useful Load		17,738 lbs.
Crew (7) and Parachutes	1,400 lbs.	
Fuel (1611 gals.)	9,666 lbs.	
Oil (90 gals.)	674 lbs.	
Guns and Ammunition	1,911 lbs.	
Bow (1) 37mm cannon	368 lbs.	
120 rds. 37mm ammunition	420 lbs.	
Mk. 9 sight	4 lbs.	
Top Waist (2) .50 cal. guns	120 lbs.	
1200 rds. .50 cal. ammunition	360 lbs.	
Adapters, solenoids, etc.	14 lbs.	
Tail (2) .50 cal. guns	120 lbs.	
1600 rds. .50 cal. ammunition	480 lbs.	
Adapters, solenoids, etc.	25 lbs.	
Bombs and Installation	2,615 lbs.	
(8) 325-lb. Depth Charges	2,600 lbs.	
Installation	15 lbs.	
Pyrotechnics	107 lbs.	
Equipment	1,365 lbs.	
Gross Weight		46,000 lbs.

Horizontal C.G. for Normal Gross Weight = 30.7% M.A.C.

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ABOUT THE AUTHOR

The events described in this article were discovered by the author during the course of research for his forthcoming book, *American Aircraft Turrets & Flexible Gun Mounts, 1916-1960.*

Mr. Hansen has written several other military aviation articles, and is the author and publisher of *The U.S.S. San Francisco (CA38): A Technical History.* He currently resides in Mountain View, California, with his wife Eleanor, and a large colony of free-loading pigeons.