

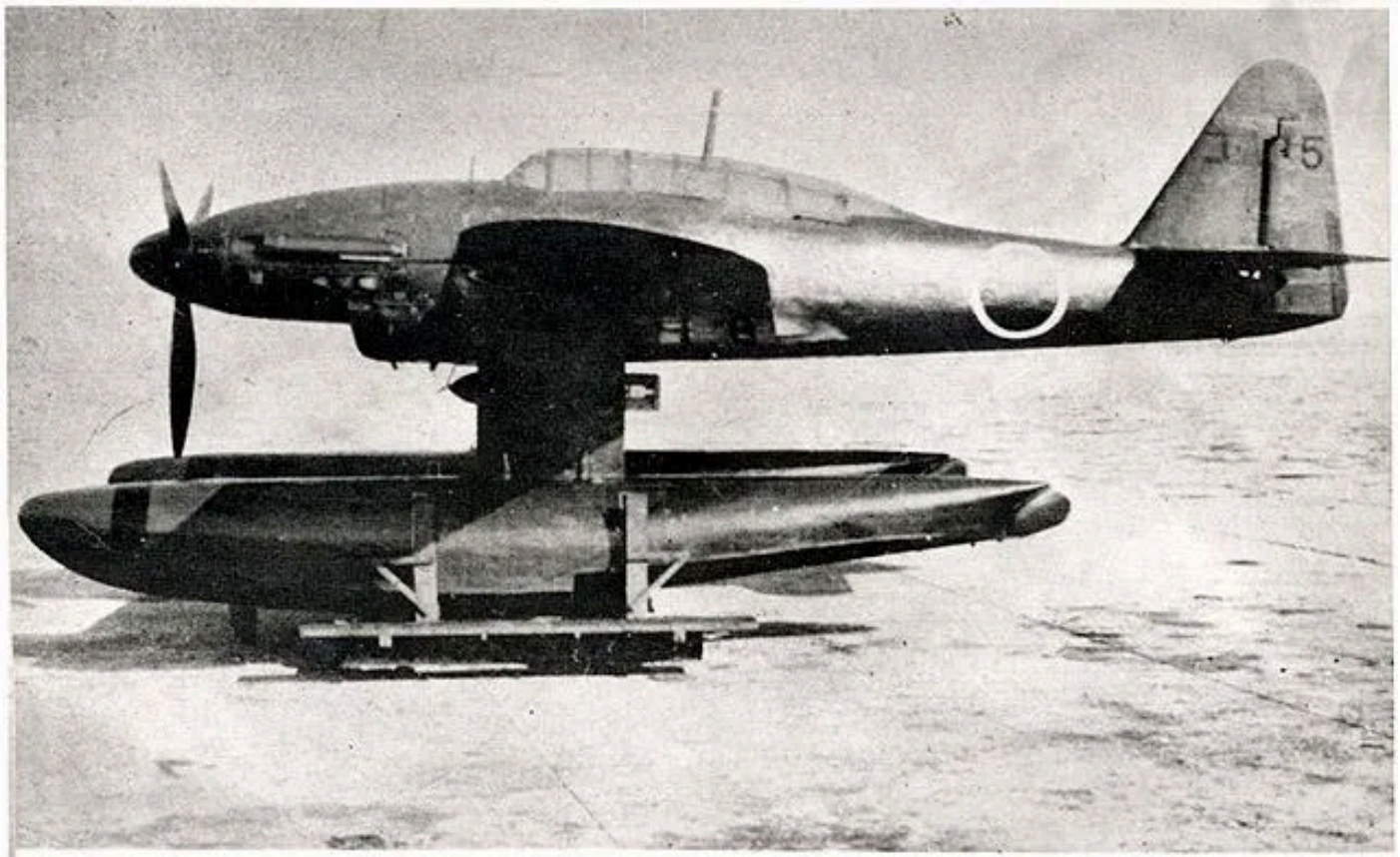
AIR & SPACE MAGAZINE

All and Nothing

After Pearl Harbor, the Japanese planned to strike the United States with aircraft borne by giant submarines.

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The Aichi M6A1 Seiran (Clear Sky Storm) (shown here on a beaching dolly) was designed to operate from a submarine.



Immediately after the December 7, 1941 attack on Pearl Harbor, Admiral of the Fleet Isoroku Yamamoto, supreme commander of the Imperial Japanese Navy's Combined Fleet and the originator of the Pearl Harbor attack strategy, met with his staff to plan the next move. The 1989 book *Phantom of Submarine Aircraft Carrier* cites an account by one of Yamamoto's staff officers that the admiral was working on another daring scheme. In the old Japanese organized crime groups, known as the yakuza, there is a gambling term—kenkon itteki, meaning “all or nothing, a one shot.” Yamamoto was no yakuza, but he knew the meaning of the words.

Japan must “put our hands” on the U.S. mainland, he said, adding: “What other means is there than the aircraft-carrying submarine?” And so, just over a month later, on January 13, 1942, the Imperial Japanese Navy's Kansei Honbu (Ships Command Headquarters) received a request from the Gunreibu (Naval Operations Command) to study the possibility of designing a “40,000-nautical-mile range submarine with a capacity to carry attack aircraft each loaded with a torpedo or 800 kg [1,764 pound] bomb.”

Elevating the Forgotten Histories of Black Wo...

When Yamamoto had been assigned to prosecute Japan's war against the mighty naval powers of the United States and Great Britain, he considered the task impossible. Still, he had hoped to score a decisive win at Pearl Harbor to gain the

upper hand in what would surely be a long and wearing war. Yamamoto knew he had to have another tactical victory if Japan were to win strategically or at least maneuver for an advantageous truce. Submarine-stowed aircraft for clandestine reconnaissance and attack against enemy ships had been built and tested by several seagoing nations as long ago as World War I. But Yamamoto's concept of using a submarine's stealth to deliver an airborne attack on strategic land targets was clearly a departure.

Japanese memoirs speculate that Yamamoto's vision for the *kenkon itteki* included targets like New York City or Washington, D.C. As planning progressed, however, the navy settled on a more pragmatic target: the Panama Canal, where a single raid, if successful, could prevent the U.S. Atlantic fleet from crossing to the Pacific. An undersea-borne air strike force would launch from the Gulf of Panama, cross Panama to the Caribbean Sea at low altitude, surprise the defenders by approaching from the Atlantic side, and bomb the critical Gatun Locks, which would put the canal out of operation for six months.

In early 1942, both the Ships Command Headquarters' submarine division and the Air Command Headquarters' Kugisho (Air Technical Bureau) began working on a submarine carrier and an attack aircraft that could be launched from it. Engineers developed two carrier submarine classes, called *sen-toku*, or special-type sub: One, an I-13-class sub, displaced 3,603 tons on the surface and had a range of 21,000 nautical miles. The larger, I-400, was 400 feet long, displaced 5,223 tons surfaced, and had a 37,500-nautical-mile range. Each was designed to carry two aircraft in a hangar tube built over the hull, but the I-400 was revised to carry three.

The aircraft designated M6A1 was one of the 17-shi (experimental aircraft initiated in the 17th year of Showa—1942) and was eventually named *Seiran*. ("Seiran" translates as *sei*, meaning "clear sky," and *ran*, meaning "storm," thus: "storm from the clear sky.") In a chapter he wrote in *Development and Records of Famous Aircraft* the *Seiran*'s chief test pilot, Tadashi Funada, explained how he conceived of the name for

the airplane: "An instruction came from the Kaigun Kouku Honbu (Naval Air Command Headquarters) to think up an appropriate name for the M6A1 Prototype Aircraft. I contemplated adding to the stealth of the submarine the 'limited visibility maneuvering ability (instrument flying skill)' of the floatplane pilots. As a metaphor for suddenly appearing out of the fog—like a Ninja—I thought of the name 'Seiran' from 'Seiran of Awazu.' " This is the title of a series of woodprints, by an 18th century master craftsman named Hiroshige, typically depicting mountain haze rising, presumably after a storm in Awazu, a picturesque town.

The design and construction were assigned by the Kugisho on May 15, 1942, to the Aichi Kouku (Aircraft) Company of Nagoya, which had already built several floatplanes for the navy. Basic design studies for the Seiran consumed Aichi for the rest of 1942, and the first prototype was completed in November 1943, followed by seven more. During 1944, flight tests at the Kugisho in Yokosuka were conducted and developmental changes made. In January 1945, the aircraft was ready for operational use.

Leadership of the project was entrusted to Aichi's chief designer, Toshio Ozaki, and the Kugisho's chief test pilot, Lieutenant Commander Tadashi Funada. The effort to design a large, high-performance attack aircraft that would fold to fit into the hangar of a submarine was one thing. More critical were the design considerations to enable the crew to launch the aircraft within the limited time during which the submarine was surfaced. The expediency of the operation and the critically limited deck space for the crew called for a high level of automation and innovative human engineering.

Ozaki has said the aircraft was originally conceived with no landing gear at all in order to attain maximum speed and range. After the mission the crew would fly back to the sub, ditch the aircraft, then be recovered aboard. Early in the aircraft design study, however, a pair of detachable floats was added as an option, based on a notion that the aircraft could attack several less significant targets before its final one-shot mission. Further, the floats would allow training flights from seaplane ramps and

submarines. The submarines were equipped with cranes to recover the airplanes after landing. A provision for jettisoning the floats in flight, although considered during the design process, was never implemented.

Two of the eight prototypes were built with hand-cranked retractable wheeled landing gear. These land-based prototypes were used to establish the aircraft's characteristics without floats—and once to conduct crew training against a simulated Panama Canal. These two M6A1-K, Shi-Sei Seiran-Kai, were given the name Nanzan (southern mountain) to distinguish them from the seagoing versions. The innovations designed into the Aichi M6A1 made it one of the most advanced and complex Japanese aircraft of the war. The aircraft was probably the one that was least known to foreign military intelligence at that time, as well as to those with technical and historical interests, even today.

The project was top secret and well concealed. Allied intelligence knew so little about the Seiran that it was not even assigned a customary English code name. It was manufactured in a detached experimental-aircraft assembly building on a corner lot of Aichi's Eitoku plant on the river's edge, a place akin to Lockheed's celebrated Skunk Works. Training was carried out at dispersed secret bases.

A 1944 Allied Air Technical Intelligence Center report, now declassified, verifies that the Allies were aware of a "330-mph class" aircraft named M6A1 or Seiran (then translated as "clear day"). The half-page description noted that the aircraft was of "unusual design" and "for submarine use," and that the nomenclature gave no hint as to its type but indicated only that it was a special aircraft made by Aichi. Allied intelligence obviously had no clue as to the mission Yamamoto had in mind for it.

Within the past few years, personal memoirs and interviews of the surviving Imperial Navy personnel involved in the Seiran and sen-toku projects have begun to appear in Japanese publications. Backed up by memoirs and chronicles by U.S. servicemen on the scene immediately after the war, these accounts collectively present a

comprehensive history of the unique development and demise of the special task force who tried to realize Yamamoto's vision.

Along with long range and endurance for a deep strike mission from the sea, the maximum speed attainable to evade fighter interceptors was critical to the success of the all-or-nothing mission. Without floats, the aircraft had a maximum design speed of 348 mph. This was comparable to the top speeds of fighters like the Grumman F6F Hellcat: 380 mph. Even with floats attached, the Seiran attained a respectable maximum speed of 295 mph at an altitude of 17,160 feet, although it couldn't have outrun most fighters.

The Atsuta engine was a type 31 or 32 water-cooled, inverted V-12 rated at 1,340 horsepower (1,400 hp maximum), manufactured by Aichi and based on the German Daimler-Benz DB601A. The propeller, based on a Hamilton Standard, just cleared the inner diameter of the sub's hangar tube. The sub's hangar had facilities for heating the engine coolant and the lubricating oil. By pumping them into the aircraft's engine just prior to launch, the crew could warm it up without actually running it. Ultimately, the decision favoring the aerodynamically clean water-cooled engine over the larger diameter air-cooled engine prevalent in the Japanese aircraft of the time was based on the loading of the long, slender torpedo under the fuselage. The inverted V-12 engine ensured that the propeller arc was well forward of the torpedo's warhead.

Next came the task of tucking the aircraft into the 11.5-foot-diameter hangar tube. One of Ozaki's engineers came up with the idea of rotating the wings forward 90 degrees around the wing spar root and then folding them rearward against the sides of the fuselage. Unfolding the wings and connecting all the control-surface linkages and fuel lines from the wing tanks would have to be done in seconds to stay within the three to four minutes of an aircraft's launch preparation time. This operation was to be performed by four launch crew members on deck—most likely in darkness. The hydraulic wing-fold mechanism was powered by a source in the sub's hangar. The deck crew would connect a hydraulic line from the sub to a receptacle in the access

panel under the fuselage at the wing root and power the unfolding actuators when the aircraft was clear of the hangar. All linkages, via various articulating mechanisms, were hooked up automatically. The deck crew merely had to hand-crank a set number of turns on the foldaway handles to seat the wing locking pins, two on each wing. Indicator arms, painted red and glow-in-the-dark phosphorescent, withdrew into the aircraft to show that the pins were set.

Three empennage tips, folded for hangar stowage, were flipped up and locked into place. The floats, when used, were mechanically rolled out of separate stowage tubes on both sides of the hangar tube as the aircraft was emerging. They were snapped onto the pylons and then onto the underside of the wings with four quick-locking pins at each float's eight attach points.

The foldaway design continued inside. A 13-mm machine gun mounted behind the navigator's seat was stowed upside down in a recess in the fuselage and rolled rightside up into shooting position, facing aft to confront pursuers. For this manipulation, the aft end of the cockpit canopy was rolled upside down and away into the same stowage space below. In the up position the gun mount was hooked up to the gunner's seat and aimed by the gunner, who used a pedal to adjust the seat vertically.

As this was to be a dive bomber, it had to be equipped with an aerodynamic dive brake to control the speed and angle of dive. Ozaki's team employed a double-slot design that combined the flap with a dive brake, an idea Aichi had successfully developed for its carrier-based attack bomber, the B7A2 Ryusei (Allied code name "Grace"). The combination flaps extended fully to lower the landing speed to 78 mph. Only the smaller flaps deployed in the dive-brake mode at continuously selective angles down to the maximum 90 degrees. The pilot would select flap or dive brake mode and flip a switch at the top of the control stick while on approach or in dive bombing.

For the one-shot raid the Japanese navy would use the largest bomb in its inventory—the 1,764-pound general-purpose bomb with a steel penetrating head—or a 1,808-pound torpedo. The back seater's primary duty was precision navigation to the target and back to the sub. This navigator-bombardier-gunner would sit in a swivel seat, usually facing forward. His panel was equipped with a set of navigation and communication gear well beyond those of most Japanese single-engine bombers.

Aboard the submarine, the aircraft was mounted at four attach points to a dolly that rolled on a rail to the inclined catapult, then served as the launching shuttle during the the catapult's 69-foot power stroke until the aircraft separated from the dolly and flew away. The launching dolly was equipped with an articulated support structure so that the aircraft would be in a low-silhouette squat position while in the hangar tube and, when rolled out of the tube onto the catapult track, would be tilted nose up for higher angle of attack during launch. The aircraft was launched in the same manner even when the floats were attached to the aircraft. The floats straddled the catapult ramp without touching the sides of the ramp or the deck surface below.

As the aircraft design evolved early into adapting the detachable floats, a somewhat subtle but potentially significant consequence developed. Both the chief and assistant test pilots, Tadashi Funada and Yukitaka Murakami, were trained and experienced solely in floatplanes flying reconnaissance missions, not in bombers. So were the squadron commander, Lieutenant Atsushi Asamura, and the rest of the pilots assigned. The inexperience of the floatplane pilots in dive bombing and torpedo launching, along with the limited time available for developing the additional skills, reportedly led the unit to abandon the use of torpedos. Further, in training and in mission planning, only a shallow dive was employed in attacks to get the best accuracy attainable within the pilots' limited expertise. This is ironic because the Seiran was one of the few aircraft in the world designed to be capable of both torpedo attack and dive bombing—besides being the first and perhaps the last sub-launched manned attack aircraft.

The Pacific war developed into the drawn-out match that Yamamoto had feared: It was a contest of national wills, armed might, and, more critically to Japan, industrial capacity. The main theater of war soon contracted to the southwestern rim of the Pacific and drew ever closer to Japan's mainland. On a tour of Japanese naval bases undertaken in a desperate attempt to boost the morale of the troops holed up in the scattered last bastions of the crumbling Empire, Yamamoto's airplane was shot down by an American P-38. With the death of the brilliant strategist, the Imperial Japanese Navy lost the force of his vision to "reach" the U.S. mainland. But the rapidly changing war situation may already have rendered the operation futile.

In 1944, war production in mainland Japan was in a shambles. The Japanese were fighting to defend what was left in Sokoku (ancestor's land). Performance and expediency, certainly not engineering elegance, had become the operative words of the military and industry. Yet at the Aichi Aircraft Company, under the watchful eyes of the Kugisho, production of the M6A1 reached 28. Four I-400-class sen-toku were being built. The I-400 and I-401 entered service with their aircraft, and the I-402 was converted to a transport submarine. A fourth one was destroyed by a U.S. air raid on its shipyard.

On December 15, 1944, Number 631 Air Squadron was established, and on December 30, Number 1 Submarine Squadron. These units were intended to make up the special task force to carry out the Panama Canal attack. As U.S. forces drew closer to Japan, headquarters strategists began to abandon the Holy Grail of Panama, instead planning to send the attack group on a more essential mission: to strike at the U.S. naval task force readying for the inevitable assault on the Japanese mainland. Japan's intelligence marked Ulithi Atoll at the western end of the Caroline Islands as the target. The idea was not received well by the Yamamoto traditionalists, particularly Captain Ryunosuke Ariizumi, who, as one of the staff analysts in the Naval Operations Command, had endorsed the original Yamamoto proposal and was now assigned as commanding officer of the Number 1 sub squadron as well as

commander of the entire sen-toku attack force. Ariizumi earnestly argued against reducing Yamamoto's strategic vision to a mere tactical stroke and pleaded to high command, but to no avail. The target of the sen-toku force mission was changed officially from the Panama Canal to Ulithi Atoll on June 25, 1945, when the order was passed to the units in training for the mission to return to home port.

The Ulithi operation consisted of two elements: Operation Hikari (Light) ordered I-13 and I-14 submarines to transport two Saiun (Nakajima C6N1, Allied code name Myrt) advanced reconnaissance aircraft aboard each ship to Truk, an island base still held by Japan approximately 900 miles east of Ulithi in the Carolines, to conduct reconnaissance flights to verify the presence of the U.S. fleet. The Saiuns' high-speed, high-altitude, long-range performance were called for in this mission to ensure success of the valuable Seiran attack force—to be launched in unrecoverable float-less configuration. The I-13 hangar designed for two big Seirans was large enough for this big, three-seat reconnaissance airplane equipped with a 2,000-hp Homare engine and developed as a carrier-based aircraft. The two ships, having replaced the Seirans with Saiuns, left Maizuru on July 2. The I-13 never made it to Truk; it was reported missing and later confirmed sunk by a U.S. destroyer.

The plan for Operation Arashi (Storm) was, true to the Seiran name, to rain storms of attack on the U.S. fleet from the southern sector, where no Japanese force was known to exist. Six Seirans, three aboard Ariizumi's I-401 flagship and three more on the I-400, thus constituted the final one-shot attack force.

There was a solemn send-off ceremony on July 19 in Maizuru—a ceremony that had become an increasingly frequent routine in the Japanese navy and army air forces in the last days of the war, as pilots of Tokko Tai (Special Attack Corps) readied themselves for their final sortie. The 12 crewmen of the six Seirans were each presented with a dagger in an unlacquered wooden scabbard—a samurai warrior's personal weapon that has not drawn blood—as a symbol of prayer for success in their last and highest mission of honor. The daggers were sent by the sixth fleet

commander in chief and personally handed out by Ariizumi. These gifts expressed an unspoken expectation that each samurai would not hesitate to make the final dive of his aircraft and dash himself and his comrade into the enemy target to ensure the success of the mission in defense of the “ancestor’s land.” That these missions were tokko (special attack), called “kamikaze” by Westerners, was solemnly understood by the flight crew, the commanders, and the nation. It may not have been written in the order of the battle, but it was implicit in the prevailing doctrine of battle, the sacred ritual, and the mounting urgency of the homeland defense. For the first time in the kenkon itteki strategy that had produced the one-mission aircraft designed for maximum effect, the mission became a truly one-way tokko attack. The world’s only sub-aircraft carrier attack force left for its final mission from Ominato, the hastily assigned home port at the northern tip of Honshu.

Published accounts, recently confirmed, of the preparation for the Ulithi attack alluded to the red hinomaru (the sun circle of the Japanese national flag) marking of the Seirans being painted over with the star markings of the U.S. forces. Another account, that the aircraft were repainted in the silver color predominant among U.S. aircraft, has not been confirmed in the recollections of those present. In a 1999 interview with National Air and Space Museum restoration specialist Robert McLean, Murakami, the Kugisho test pilot who had performed the final flight check of the Seirans at Maizuru base, remembered his astonishment and shame when he saw the U.S. star on the folded wing of a Seiran on the deck of an I-400 submarine. He could hardly believe that the Imperial Japanese Navy would resort to such deception. Asamura, the 631st squadron’s flight leader, told McLean that “the Ulithi attack was a ‘one in thousands’ chance.” If mistaking the Seirans for P-51s could cause the American defenders to hesitate for one second, he continued, at least one or two aircraft may be able to get through to hit an American warship. “Thus the intense desire to succeed in the slim-chance attack overrode the shame of the acknowledgedly ‘cowardly’ tactic,” Asamura said.

On August 15, 1945, even as the elements of the force headed toward their rendezvous point for attack, Emperor Hirohito announced Japan's surrender to the Allied powers. The submarines were instructed to disarm and return to their home ports, cruising on the surface and flying a black triangular flag in accordance with the surrender agreement. The special force's main weapon systems, the revered Seiran M6A1s, were scuttled—launched, with wings folded, from the I-400s' catapults to sink into the depths of the Pacific.

And so the product of Admiral Yamamoto's elaborate strategy to bring the war to the U.S. mainland came to an end. Captain Ariizumi took his own life in his command ship's cabin, observing an ancient tradition when faced with the dishonor of surrender, a concept that is not in the vocabulary of the samurai.

The sen-toku submarines were sailed to Pearl Harbor by a U.S. Navy crew for technical assessment and were subsequently scuttled at sea off Hawaii. The submarines, I-401, I-400, and I-14 followed their aircraft to the deep.

The chaotic aftermath of Japan's surrender and the hasty collection and shipment to the United States of samples of Japanese warplanes by the Allied Air Technical Intelligence Group revealed no special notice of the heretofore secret aircraft. Fortunately, the shipment included at least one Seiran, which eventually found its way to Washington, D.C., to be preserved as the only remaining example in the world.

The I-400 sen-toku had been the largest submarine in the world ever to sail until the U.S. Navy launched the nuclear submarine USS Triton in 1959. Author E. John Long, in the October 1953 issue of *Ships and the Sea*, described the first U.S. encounter with the sen-toku: "Twelve days after the Mikado told his people to lay down their arms, one of Japan's most closely guarded secrets was revealed. The pilot of the U.S. Navy patrol plane could scarcely believe his eyes. The great dark object, half awash, looked like a floating wreck. It seemed too big to be a sub—but it was one, on the lam."

Recently, the staff at the Paul E. Garber Preservation, Restoration, and Storage Facility in Suitland, Maryland, completed a lengthy restoration of the surviving Seiran (see “Team Seiran, p. 26). While searching records in Japan, staff members met individuals involved in the design of the airplane, and they were able to tell their stories. The restored Seiran will re-tell the story for years to come.

Team Seiran

In terms of the challenges it posed to the staff at the National Air and Space Museum’s Paul E. Garber Preservation, Restoration, and Storage Facility in Suitland, the Aichi Seiran is without peer. Here are the restorers’ recollections of the project:

Bob Weihrauch: When we got our first look at the floats, they looked in good shape from the top, but when we looked at the bottoms, we could see internal damage. It was all aluminum except for steel fittings where it attaches to the airframe. Dust and debris were falling out of holes in the skin.

We knew most of the work would be on the bottoms, so we turned the floats upside down and started removing the skin panels. We knew we couldn’t just do a cosmetic repair because the aircraft would be displayed on its floats, so the floats had to be structurally sound.

Some sections had rivets that had completely turned to powder. The corrosion looked like it probably started on the inside and worked out. The float had probably filled with water—in fact, we could make out a water line inside it.

We took out the bad sections on one entire float and made wooden forms from the original parts. We used these to hand-form the replacement sections from .040-inch aluminum sheet. We annealed [softened] the aluminum and shaped it with a mallet.

We did 75 percent of the re-skinning job solo until we got to the keel, which is on top with the floats flipped the way they were. The access hatches that would normally be on top of the float were on the bottom where a person could crawl inside with a light and a fan and a whole bunch of bucking bars. Because of the location of some of the rivets, we had to fabricate bucking bars. Finally we got to where we had to have someone inside the float. A person can work about two hours in there before they have to come out. Once they were inside it wasn't too bad. But getting in was tough.

Tyrone Stewart: [I worked inside the floats] for about three weeks, and it was hot in there! The hardest part was near the end portions, where the float narrows. I had to crawl out, then climb back in again every time I needed to change my position.

Bill Reese: The engine was taken off the firewall and set vertically while we worked on it. It was fairly easy to remove. We pulled the cover off the bottom of the block to see the big ends of the connecting rods and crank. We looked inside the cylinders and saw that there was only a light coating of carbon, so it had less than 10 hours on it. We went inside with a spray wand and some corrosion inhibitor and did some touching up here and there. There were no earth-shattering surprises. It was fun for me as a mechanic to work on such a rare engine. It's complicated, and it's a big chunk of metal—that made it a lot of fun. But curiosity is not a good enough reason to tear an engine completely down. You start tearing it down and you can do more damage than if you leave it alone.

Matthew Nazzaro: The fuselage had been outside most of the time, so it had sun and water damage. Souvenir hunters had been at it as well. There were areas where aluminum and steel were joined without coatings between them, setting up electrolytic corrosion cells.

Robert McLean: The first record of the [propeller spinner that accompanied the Seiran] was some photographs taken around 1960 when the aircraft was on display at an open house at the naval air station in Alameda, California. There is a mysterious

blue spinner nose that didn't look right in these photographs, and later, during restoration, we found that this blue nose section didn't really fit the spinner base, leaving a gap. The shape didn't look right, the color was wrong, and rivet holes at the rear end of the spinner nose had no purpose.

Inside this blue spinner was penciled "RH" in an English or European alphabet, which suggests that this was not a Japanese spinner and possibly was the right-hand spinner of a twin-engine airplane.

Nazzaro: [After studying photographs] we decided that the spinner nose of the Suisei [the Japanese "Judy," similar to the Seiran] was longer than that of the Seiran, but the actual spinner bases from the two aircraft were identical. This provided us with an excellent starting point, knowing that all that was needed to plan the new Seiran replica spinner nose was an updated profile, with construction techniques based on the longer Suisei nose.

McLean: Using photo-interpretive techniques, a profile was developed and made into cardboard templates. These templates were physically held up to the spinner base and the propeller hub temporarily mounted to the Seiran. We visually compared it to the photographs of the airplane, and we all agreed that it looked right. We then contracted to have a replacement spinner nose spun to those dimensions.

When we received a resin model kit of the Seiran and its highly detailed brochure, we saw factory drawings of entire subassemblies—the rear gun and how it moved, and the rear-seat articulation. Our volunteer, Hiroyuki Nagashima, remembered building this model and found us another kit and had it delivered to the United States by a friend who came here on a visit.

Nazzaro: The model kit was the first important data milestone. After that it was like a flower opening; more information began to flow. There were still many mysteries about the airplane: brackets that you could only guess the purpose of, or large empty areas surrounded by fabric snaps.

Karl Heinzl: [The wing] was beat up and covered in cosmoline. The wooden wingtips were busted up and the sheet metal was bulged around where the spar was corroded.

Anne McCombs: One wing served as an example while the other was apart so we could always refer to it. It also had a lot of acorns in it, so obviously some squirrels had been in residence.

Heinzl: [Inside it] the interesting stuff was the drawings. A guy had written the alphabet in English with no letter L—there's no equivalent Japanese sound for L. There were some cartoon mice, a really nice geisha, a car, and two airplanes, one apparently on fire.

McCombs: There were numbers on each rib that would say "aircraft 12, rib 4" or just "12/4"—it took us a while to figure out.

Heinzl: Bill Stevenson welded in some patches, and the weld won't take unless the corrosion is completely gone, so you know that if the weld is okay, you removed all the corrosion.

Scott Wood: The original lens covers, the green and red lenses on the wingtip lights, were all busted up. I had to make a wooden mold in the shape of the lenses, so I taped the red one together to use for a pattern. I didn't have the right thickness of Plexiglas, so I wet-sanded it down to get the right thickness and then polished it. I took that finished piece and heated it, then shaped the heated plastic with hand seamers until it fit the wooden mold.

Heinzl: [During the corrosion cleanup] we had to build a box frame around the wing-stand assembly and cover it with plastic, then get inside and blast. So we're working in protective suits inside this enclosure to contain the dust, and someone painted some fish on the outside, so it looked like an aquarium with a guy in a diving suit walking around inside it.

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