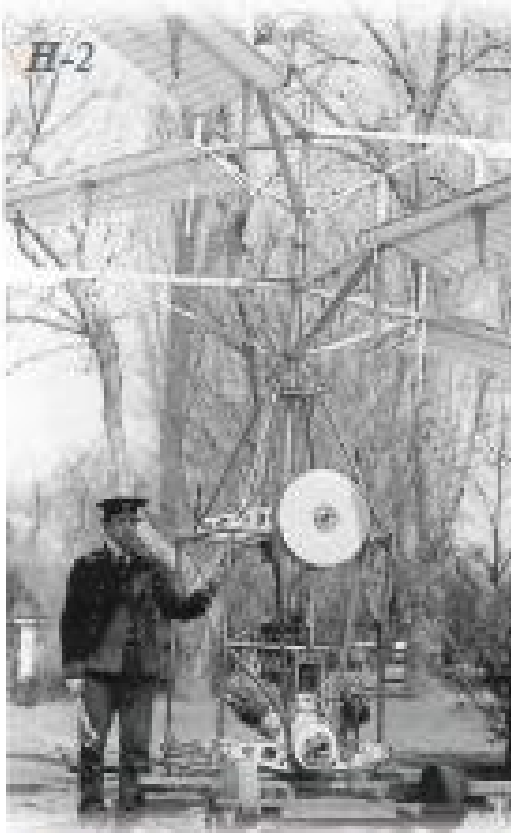


Sikorsky Archives News

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Evolution of the Sikorsky Utility Helicopter



Igor Sikorsky started his aviation career in 1909 by building two experimental helicopters. He stated that the first of these ships refused to leave the ground while the second could lift itself, but refused to lift him. After a successful career in aviation designing and building

airplanes and seaplanes, he returned to his first love, and successfully built and flew the first practical helicopter in the world in 1939. This issue is devoted to Utility Helicopters which have gross weights between 6,000 to 22,000 pounds. Missions include carrying passengers,

internal and external cargo, medivac and rescue, construction and fire-fighting.

Data has been obtained from Ray Leon's essay titled, "Sikorsky Utility Helicopters-A Hard Beginning", dated December, 2011. Ray is a coauthor for this issue. ☺

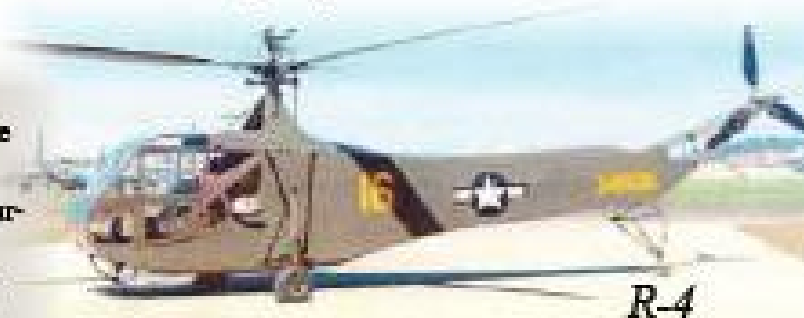


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Igor Sikorsky's experimental aircraft the S-46 (VS-300), successfully flew in 1939, which led directly to the S-47 (R-4) first production helicopter produced in the world creating a whole new industry.

The R-4 and its successors provided a small glimpse into how the helicopter might serve in war and peace as a vehicle of rescue and assistance for humanitarian purposes. The aircraft's unique capability to rescue people in distress from places that were inaccessible by other means was demonstrated in April 1944 in the jungles of Burma when an R-4 rescued one pilot and three wounded soldiers in Japanese held territory, making three trips to do so. The next year, in November 1945, an R-5 performed the first civilian rescue by lifting two crewmen from a barge being blown toward the rocks at Penfield Reef during a raging northeaster on Long Island Sound.

Those and other early helicopter successes ignited the imagination of aeronautical designers, aircraft builders and potential helicopter operators around the world. The R-4 design used Igor Sikorsky's single main rotor and tail rotor design that evolved from numerous variations and quantity of horizontal and vertical tail rotor configurations that he envisioned and flew on his VS-300 experimental aircraft.



R-4

The R-4 was a larger helicopter than the VS-300. It had a 38 foot main rotor compared to the 30 foot on the VS-300. Its engine was a 200 HP Warner R-550. Gross weight at 2540 was more than double that of the VS-300. Empty weight was 2011 lbs.

During the decade of the 1940s, the R-4, R-5, R-6 and their variants were built as light helicopters capable of carrying up to 5 people. Over 400 units were produced during the World War II time period with production rates reaching ten aircraft per month. The success of these small light gross weight helicopters, coupled with the growing awareness of the helicopter's unique vertical flight capabilities, encouraged other prospective manufacturers to enter the marketplace with their own innovative designs.

At the same time, the customer envisioned new missions that only the helicopter could perform. These new missions required aircraft that could carry greater payloads for troops and cargo transport with expanded operating ranges involving naval shipboard operations and anti submarine warfare. Nearly all of these missions were for helicopters that fit within what is now considered to be the utility or intermediate size category, effectively creating the beginning of the utility transport market. ☺



S-47 (R-4)



S-51 (R-5)



S-49 (R-6)



S-52 (R-10)

During the post World War II years, heavier gross weight helicopters with increased performance were required. Sikorsky Aircraft realized that design innovation and creativity were needed for the company to be a success in the heavier gross weight emerging utility markets.

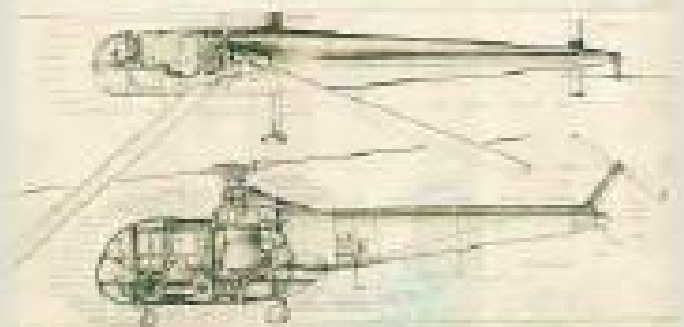
The euphoria of the R-4 series production records soon turned to despair when the company realized that the successful R-4 design could not be scaled up to larger sizes, nor could that configuration be competitive with emerging new designs offered by other companies.

Sikorsky's initial entry into this emerging utility market was the S-53 (XH3S-1) in response to the U.S. Navy's competition for an amphibious aircraft. The S-53 was a relatively large helicopter at the time with a gross weight of 5500 pounds. It was powered by a Continental R-795-34 engine rated at 525HP. Piasecki entered the competition with the XH1P-1 tandem rotor helicopter. Both helicopters used the same engine models.

The increased size and systems arrangement patterned after the earlier models limited the S-53's overall effectiveness. Per the earlier models developed at Sikorsky, the engine location in the S-53 was directly below the main rotor resulting in all payload being placed forward of the main rotor rotational axis limiting the Center of Gravity (CG) envelope. This limited CG control range was one of the major factors for Sikorsky losing the Navy contract to Piasecki, and later losing to Bell's first and last tandem rotor HSL helicopters.



S-53



The emergence of the tandem rotor design encouraged Sikorsky pioneers to consider adding a horizontal tail rotor to their single main rotor configuration as a means of providing greater pitching moments to compensate for CG excursion. This new approach of two horizontal rotors and one tail rotor was embodied in the experimental S-54 model. The configuration was called a sesqui-tandem design and was similar to an experimental configuration tried during the evolution of the VS-300 helicopter.

The S-54 was built by modifying an existing R-4B that was borrowed from the U.S. Air Force. The S-54 made its first flight on December 20, 1948 and was retired in early 1949 after having been flown 4 hours and 20 minutes. This S-54 configuration was found to produce the desired results, however it was too complex and ungainly to be considered as the right solution. ☺



The Sikorsky Sesqui-tandem period 1939-1949

VS-300

S-54

Two major design innovations introduced during the late 1940s permitted the design of larger single rotor helicopters having large cabin volume and unprecedented control power.

Both innovations were implemented and flown on the S-55, which made its first flight in November 1949 less than one year from go ahead. This new model was able to demonstrate its capabilities in time to rescue Sikorsky's position in the industry. These design innovations paved the way for Sikorsky to enter the utility transport market with a single main rotor configuration able to challenge Frank Piasecki's successful tandem rotor design.

Sikorsky's Chief of Advanced Design and later Chief Engineer, Edward F. Katzenberger created the first major innovation. He relocated the piston engine from under the rotor to a location forward of the cabin and below the cockpit. This change provided a spacious cabin compartment directly below the main rotor, allowing payload to be carried near the aircraft's CG, and essentially in line with the rotor's rotational axis. This location made the engine more accessible for ground maintenance via large nose clamshell doors that opened to expose the engine at ground level. The engine was tilted on an angle resulting in the output drive shaft being in line with the main gearbox input, and connected via an input drive shaft, clutch and engine cooling fan. The pilot cockpit was accessible via a short stairway from the cabin.



Don Fowler, flight mechanic is holding the clam shell door open. He later was the Experimental Hangar Operations Manager



H-19 Clam Shell Door closed

The second innovation was related to the main rotor head configuration. Sikorsky main rotors have generally been of the fully articulated design in which the blades are free to flap up and down as well as to lead or lag in response to aerodynamic and inertia forces. This freedom of motion was provided by flap hinges and lag hinges. Prior to the mid 1950s, the hinges were designed with the flap axis located on the rotor rotational axis to reduce vibratory loads in the rotor head and airframe. The control power required to change aircraft pitch and roll attitudes with this configuration is limited. The innovation that solved this problem was the creation of the offset flapping hinge concept designed by Ralph Alex. It was first flown on Sikorsky's S-52 providing a high level of control power, which allowed the aircraft to be the first helicopter to perform a 360 degree loop maneuver as well as to demonstrate unprecedented agility. 🍷



S-55 Main Rotor and Main Gearbox Assembly

Major new design innovations developed through the 1950s, and were incorporated in virtually every helicopter worldwide accelerating the rapid expansion of the utility market.



The development of irreversible hydraulic servos to assist the pilot in controlling helicopter flight loads was the first major breakthrough during this period. Early Sikorsky models like the S-51 employed irreversible mechanical jackscrews to minimize and isolate rotor blade control loads from the pilot's cyclic and collective controls, but that approach was not practical for larger helicopters due to the friction and push rod forces severely limiting the pilot's ability to achieve precise control.

Walter Gerstenberger, a pioneer in the field of dynamics at Sikorsky, proposed the idea of using hydraulically powered controls to overcome this problem. While other helicopter innovators attacked this problem with mechanical stabilizer bars and servo tabs, Gerstenberger took the brute force approach, which was just beginning to be developed by the fixed wing industry.

Gerstenberger went well beyond the fixed wing practice of using only booster servos on large aircraft by proposing irreversible hydraulic servo controls on all axes for all helicopters. In the late 1940s, hydraulic servos were test flown on a modified S-51 with very enthusiastic acceptance by the pilot, who no longer had to fight the controls. Irreversible hydraulic servo controls became standard for all subsequent Sikorsky models with the S-55 being the first model to incorporate them.

The second major development during this period was the electronic flight stabilization system that has become an essential element of nearly all helicop-

ter flight control systems. Gerstenberger was among the earliest engineer to recognize the need for such a stabilization system when Sikorsky's S-58 was being adapted for Anti-Submarine Warfare (ASW) missions as the HSS-1N for the U.S. Navy. The problem faced by pilots in trying to hover an unstable aircraft at night during bad weather, while managing four independent degrees of freedom, seemed insurmountable without assistance. The approach being pursued by other innovators was based on using a conventional fixed-wing autopilot together with special instrumentation. Gerstenberger conceived the idea of using a limited authority control stick steering concept to introduce the feedback control inputs.

This revolutionary concept was reduced to practice by Sikorsky engineer Ted Carter, who led a three man team of electronic engineer Harold Oakes, hydraulics specialist Henry Angel, and test pilot Jack Stultz to design and develop the final design. The United Aircraft Corporation recognized the team for their contributions to achieve successful helicopter instrument flight capability in 1958 by awarding him the George Meade Gold Medal and his team silver medals for outstanding engineering achievement. This unique approach to automatic stabilization system design was found to be essential for anti-submarine warfare missions and has been incorporated in all subsequent Sikorsky models for all missions.

Capturing and Maintaining Leadership in the Utility Market



S-61 (SH-3)



SH-3



VH-3

The four critical new technologies led to a succession of very successful Sikorsky utility helicopters. In the 1950s, Sikorsky began producing the S-55 (H-19) and S-58 (H-34) utility transport models that were designed with their reciprocating engines installed forward of the cabin and below the cockpit. The resulting large cabins, together with excellent rotor control power, irreversible hydraulic control servos, and automatic stability augmentation systems contributed to their wide acceptance by U.S. and foreign military and commercial organizations. Both models set production records with the S-55 first reaching 1281 units and the S-58 later reaching 1821 units including foreign licensee production. These two models were the first true utility helicopters and became the first troop carrying helicopters for the U.S.

Army and the U.S. Marine Corp during the war in Korea. Their ability to quickly move troops independent of terrain contributed to the formulation of the Army's airborne operational concept.

The development and introduction of shaft turbine engines in the late 1950s to early 1960s completely solved the engine placement problem for newly designed helicopters. Their smaller size permitted locating the engine near the rotor and above the cabin for single rotor helicopters, and for providing dual engine redundancy. The first major Sikorsky program to benefit from the turbine engine was the S-61 (SH-3) ASW helicopter. The S-55 and S-58 were turbined to the S-62 and S-58T resulting in extending the useful life of the aircraft due to the turbine engines.



S-61 Oil Rig Support



S-62



S-58T

During the late 1960s to early 1970s, Sikorsky's production business fell to an all time low, and the company's management made a strategic decision to invest in research and development programs for advanced technologies in vibration control, main rotor pylon air flow control to reduce tail excitations, development of elastomeric bearings, titanium metal rotor blade technology, and canted bearingless tail rotors. Sikorsky led the industry on technologies relative to the single main rotor configuration. During this lean production period, Sikorsky led the contract R&D business compared to the total R&D business of the rest of the U.S. helicopter industry. Sikorsky's newly developed technologies were fully demonstrated and looking for a new home. ☺

The new design opportunity came in with the emergence of the Army's Utility Tactical transport Aircraft System (UTTAS) design specification, issued to industry in 1972.



The design specification took full advantage of the operational lessons learned from the Viet Nam war. The intense industry competition to win the UTTAS prototype award, followed 52 months later by an even more intense competition to win the Black Hawk production award is well documented in the book titled, "Black Hawk, The Story of a World Class Helicopter" written by Ray D. Leoni.

The UH-60M is the most current of the H-60 series that have been in continuous production for nearly

35 years for the U.S. Army. In total over 3000 UH-60 models have been delivered to foreign and U.S. military operators as of early 2012.

The SH-60B Seahawk that was the first derivative of the original UH-60A spawned a long line of variants for the U.S. Navy as well as for international naval organizations. Their missions include inner and outer zone ASW protection, anti-surface ship warfare, search and rescue, vertical replenishment, and vertical on-board delivery. 🌀



The S-76 was launched in the 1975 time period as the first Sikorsky model to be designed for the commercial and offshore oil support market.

The S-76 has had a series of different engine options based on the mission requirements for the aircraft. The missions cover a spectrum of corporate, offshore oil, medivac and general aviation operations up to 14,000 pound gross weight. The interiors can be

built for 6 passenger VIP corporate to 12 passenger general aviation requirements. The technology basis for the S-76 benefits from the Utility Tactical Transport Aircraft System (UTTAS) developed and built for the U.S. Military organizations. 🌀

The S-92 was developed during the 1990s to serve as both a commercial and as a military troop/cargo carrier.

The aircraft systems benefit from the proven technologies of the Black Hawk models. The aircraft structural and dynamic component designs were based on the latest flaw tolerant FAA requirements, which has proven in service to be more robust than any helicopter developed in the world to date. Sikorsky was awarded the 2002 Collier Trophy by the National Aeronautics Association acknowledging its achievements in enhanced safety. 🌀

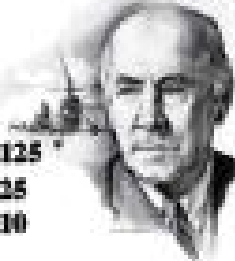


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The Utility Helicopter will continue to be a major driver for the helicopter industry in the future.

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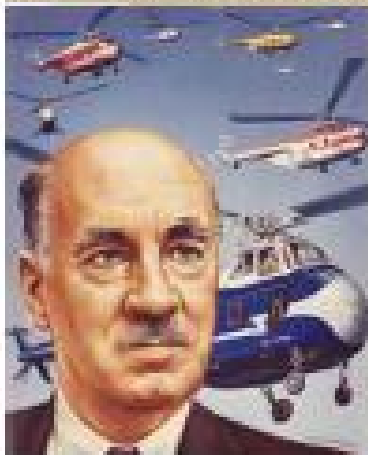
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Newsletter designed and edited by Lee Jacobson and Sikorsky Archive Members with graphic assistance by Edgar A. Gorman of Schodesign.



"The work of the individual still remains the spark that moves mankind ahead even more than teamwork."

Igor Sikorsky

