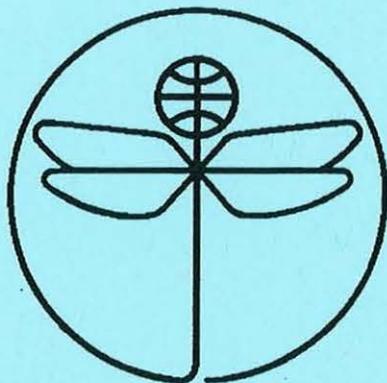


TWENTY FIRST EUROPEAN ROTORCRAFT FORUM



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**THE DEVELOPMENT OF THE VS-300 HELICOPTER**

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## THE DEVELOPMENT OF THE VS-300 HELICOPTER

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### Abstract

Igor Sikorsky first started experimenting with the helicopter as a young man in Kiev, Russia, in 1909 and 1910. After building two helicopters, he "temporarily postponed" further helicopter work and earned international fame with the design of the first four-motored aircraft to fly successfully, the "Grand", in early 1913. After moving to America in 1919, he designed a series of highly-successful long-range flying boats, but continued research on the helicopter. In 1939, he built an experimental machine, the VS-300. He chose a configuration using a single main lifting rotor and a smaller tail rotor to counteract torque and provide directional control. During the following two years, a variety of configurations were tested while slowly gaining experience in the concept of the cyclic control. By early 1942, the concept of the single main lifting rotor helicopter had been proven and the technology established to permit the start of mass production of a larger helicopter, the XR-4.

Igor Sikorsky would often say "The idea of a machine that could lift itself from the ground and hover motionless in the air was probably born at the same time that man began to dream of building a flying machine." He also found it interesting that all of mankind's early legends of magic flying machines and animals such as the flying carpet of the Persian, the flying thrones and flying dragons of Asian mythology, all these had one thing in common; they were all VTOL-capable...none of them needed a runway!

In 1908, the Wright brothers travelled to France and, that summer, made their first public demonstration flights near Paris. The flights were an international sensation; photographs and stories were printed all over Europe. When Igor Sikorsky read the reports, he determined that he would make aviation his career. In 1909, at the age of twenty, young Igor spent several months in Paris which was then the aeronautical capital of Europe. He learned all he could about aviation from meetings with the early pioneers, bought himself a 25-horsepower Anzani engine, and then returned to his home in Kiev.

His first aircraft was his first love, the helicopter. Built by hand in the back yard

of his home, it gave him much valuable practical experience, but it was far too underpowered to fly. In the fall and winter, he built a second helicopter which he tested in the spring of 1910. Again, the second machine was unable to fly due to lack of enough power, but it was obviously of better design. In a decision of great importance, Igor decided to temporarily postpone any further helicopter research and began to build a series of airplanes.

With these early airplanes, Igor Sikorsky learned how to design aircraft, and then taught himself how to fly them. In a surprisingly brief two years, he designed, constructed and flew no less than six experimental aircraft. By late 1912, he was firmly established as one of Russia's leading aircraft designers and pilots. In the spring of 1913, Igor Sikorsky made aviation history by building and successfully flying the world's first four-motored aircraft, the "Grand", or Russian Knight, as it was formally called. The "Grand" was, in effect, the prototype for a series of bigger and much improved four-engined aircraft that would be called the "Ilya Mourometz" series and would be, for several years, the biggest military aircraft operated during World War One.

After the Communist Revolution of 1917, Igor Sikorsky left Russia and eventually settled in America. By the mid-1920's, he started the second phase of his aviation career with a series of increasingly-successful commercial flying boats, or "Clipper Ships" of the air which pioneered scheduled air service across both the Atlantic and Pacific oceans. However, the challenge of the helicopter was always in the back of his mind. Starting in the early 1930's, a series of drawings and reports begin to show the gradual evolution, in his mind, of a helicopter with a single main lifting rotor and a smaller tail rotor to control torque.

In late 1938, Igor Sikorsky approached the management of United Aircraft, now United Technologies, with the proposal that they approve the building of a small experimental helicopter. United Aircraft management, which had bought Sikorsky Aircraft in 1929, was understandably skeptical. Even though a number of helicopters had been built, starting with Cornu in 1907 and Breguet in 1908, none had gone into production. In addition, Igor Sikorsky proposed building a single-rotor design, a configuration which most aviation experts considered to be impractical, if not impossible. His critics could point out to the fact that all the helicopters built to date that showed any degree of success were multi-rotor machines. In 1938, all the known helicopters that had been recognized by the FAI as having established a record were multirotor; D'Ascanio, in 1930, was co-axial; Breguet, in 1938, also co-axial; Focke in 1938 was side-by-side. Since there was no knowledge of TsAGI's work of 1933 through 1938, opinion against the single-rotor concept was almost overwhelming.

Interestingly, despite the prevailing opinions of many of its technical advisors, the management of United Aircraft approved Igor Sikorsky's project in late December of 1938. By the early spring of 1939, the basic design work seems to have been completed. The basic layout of the VS-300 was a small single-rotor helicopter powered by a 65-horsepower Lycoming engine. The main rotor was three-bladed, some twenty-eight feet in diameter. The tail rotor was single-bladed and counterbalanced in the earliest versions. The gross weight was 1,092 pounds. No effort was made to make the helicopter pretty; it was basically an open framework which could, and often was, rebuilt literally overnight.

During all of our research at Sikorsky Aircraft on the history of this machine, we have been able to find only four simple engineering drawings that describe the control system and rotor head. All the other details, such as fuselage, landing gear seem to have been described verbally by Igor Sikorsky to his small group of White Russian engineers who then improvised the hardware. The tail gear box was actually the differential from an old Ford pick-up truck: the pilot's seat was from a Curtiss "Jenny" World War One training plane.

Concurrently with the construction of the VS-300, a simple flight simulator was built, powered by small electric motors. It was used during the spring and early summer by Sikorsky to train himself in preparation for the actual flights.

On September 14, 1939, Igor Sikorsky made his first successful liftoff in the machine. During the fall of 1939, the VS-300 was used to expand the envelope and to explore stability and control. Today, we strongly suspect that these flights were made with the cyclic control system mis-phased by at least 30 degrees. It seems that the 90-degree phase shift of the articulated rotor was not fully understood by that small group of helicopter researchers.

In addition to the helicopter's instability, it must be remembered that Sikorsky was carefully teaching himself to fly this new and challenging machine. His own words describe it very accurately. "It was a wonderful chance to relive one's life all over again...to design and construct a new type of flying machine without really knowing how to do it, and then climb into the pilot's seat and try to fly it...without ever having flown a helicopter before."

By November, 1939, swiveling landing gear had replaced the earlier fixed main gear. Balance weights were added to correct an aft C.G. condition. However, stability and control remained a problem.

Suddenly, the VS-300 program changed, as the U.S. Government announced a competition for the design and manufacture of a rotary-wing aircraft to explore the military potential of this new concept. Seven designs were submitted; five were improved autogyro designs, while Platt-LePage and Sikorsky submitted helicopter proposals. The Platt-LePage machine was based on the Focke side-by-side scheme

while Sikorsky proposed a slightly-larger, two place VS-300.

In December, 1939, the VS-300 was severely damaged during a training flight when it was rolled over by a gust of wind. While being repaired, it was extensively modified. The box beam carrying the tail rotor was replaced by a truss tail section now carrying two horizontal tail rotors as well as the anti-torque rotor. But the most important change was elimination of main rotor cyclic control. Only collective pitch was retained; fore and aft flight was induced by increasing or decreasing the pitch of the horizontal tail rotors while differing pitch of the tail rotors rolled the helicopter left or right.

During March, 1940, the VS-300 resumed tethered flight testing, while Igor Sikorsky carefully tested the stability and control response of the new configuration. In May, the tether lines were removed and free flight resumed. This was due to the improved stability of the new configuration and the fact that the test pilot was gaining confidence in his piloting technique. That same month, Sikorsky Aircraft submitted a new, last-minute proposal to Washington. The revised plan closely followed the new, three tail rotor configuration of the VS-300.

On July 19, 1940, the US Government decided to award the helicopter contract to Platt-LePage in Philadelphia. The evaluators had decided that the side-by-side configuration, already proven by Professor Focke in Germany, was a lesser risk than the unproven single-rotor solution proposed by Sikorsky.

Despite the negative decision, Igor Sikorsky decided to accelerate the test program. The 65-hp Lycoming was replaced by a 90-hp Franklin. As pilot confidence and technique improved, longer free flights were logged, with some hovering flights of twenty minutes and more being recorded. Although the VS-300 was now hovering and flying slowly sideways and backwards, anytime that forward flight speed went beyond twenty to twenty-five miles per hour, the helicopter would begin to become increasingly uncontrollable and unstable. At first, it was thought that the problem was caused by main rotor downwash impacting the horizontal tail rotors.

In the midsummer of 1940, the outriggers supporting the two horizontal tail rotors were extended outwards and canted upwards to get the rotors out of the main rotor down wash. Forward flight stability improved slightly. A study of VS-300 photographs of that period shows no modifications to the main rotor head, which still carries the hydraulic dampers in the vertical position, to smooth out flapping, while lead-lag damping of the main rotor blades was by rubber friction dampers alone.

On October 14, 1940, the VS-300 had a second serious crash when one of the horizontal tail booms folded up in flight. The helicopter rolled over in the air and crashed nearly inverted. By a miracle, Igor Sikorsky was unhurt. By November, the helicopter had been rebuilt. Among the changes made were the following. The tail rotor booms were completely straight, while the tail rotor shafts were lengthened to raise the tail rotors much higher, and the tail rotor was also raised in an effort to get

it out of the main rotor downwash. In January of 1941, flight testing was resumed.

That same month, Igor Sikorsky and his small group of believers were told that Washington had decided to issue a contract to Sikorsky for a two-place observation and training helicopter powered by a 160-hp Warner engine. The news was received with understandable enthusiasm.

In April of 1940, it was decided to attempt an American endurance record with the VS-300. On April 15, Igor Sikorsky lifted into a high hover and stayed in flight for one hour, five minutes, to establish (for the first time) an American helicopter record. Since this flight was only fifteen minutes short of the World Record set by the Focke Fa-61, it was decided to go for the new record. An oversize fuel tank was fitted to the aircraft. On May 6, Igor Sikorsky stepped in front of a large crowd of official witnesses, reporters and cameramen to announce "Ladies and Gentlemen, I am afraid that you are about to witness a most boring event..." When he took off, the assembled crowd, settled down to wait. One hour and twenty minutes later, applause broke out as a Sikorsky mechanic, Bob McKellar, held up a sign that read "World Record BROKEN". Some twelve minutes later, Igor Sikorsky landed the VS-300 in front of a cheering crowd, having established a new World Record of one hour, thirty-two minutes and twenty-six seconds.

In June, the crucial decision was made to return to full cyclic control for the main rotor. Minor control problems were resolved, but the most important advance was the mastery of the control precession rigging required for the main rotor. As the control improved, another milestone was reached with the decision to reduce the horizontal tail rotors by one. The remaining horizontal tail rotor was mounted on a tall pylon just ahead of the tail rotor. The resultant sesqui-tandem configuration logged over two hours of flight time, during which time it was generally accepted that a major break-through in control had been achieved.

In October, 1941, the VS-300 was given a new, three-bladed horizontal tail rotor. As confidence increased, higher forward speeds were explored. In the flight test reports, increasing mention is made of ground and air "rocking". Today, we would probably use the word resonance. By the end of November, the decision was made to remove the horizontal tail rotor and its pylon and to return to the original concept of a single main rotor with full cyclic control and a single tail rotor for torque and rudder control.

On December 8, 1941, one day after Pearl Harbor, the VS-300 made its first flight in the new configuration. The test logs record improving control and stability, but the rocking persists and builds up as speed increases. Then, at the end of December, Igor Sikorsky makes the final, break-through decision to reposition the oleo struts from their vertical position to a horizontal position to damp the fore and aft movement of the main rotor blades. The first flight with the new oleo position was on December 31, 1941, and a dramatic improvement in flight control was immediately recorded. Further test flights in early January of 1942 showed a steady expansion

of the VS-300's flight envelope. As the fine-tuning of the VS-300 control system was proven in flight, it was immediately incorporated in the prototype XR-4, which was almost ready for roll-out.

The XR-4 made its first flight on January 14, 1942. It was evident that Igor Sikorsky was fairly confident of the technology developed by the VS-300, because the prototype XR-4 made a total of six test flights on that first day, logging a total of 25 minutes. By April 20, the XR-4 had matured to the point that it made its first public demonstration to a large group of senior Government representatives and invited Allied Forces officers. In early May, the XR-4 flew from Stratford, Connecticut to Wright Field in Dayton, Ohio, a distance of 761 miles. The five-day flight established a number of helicopter records, but they could not be published due to military secrecy regulations.

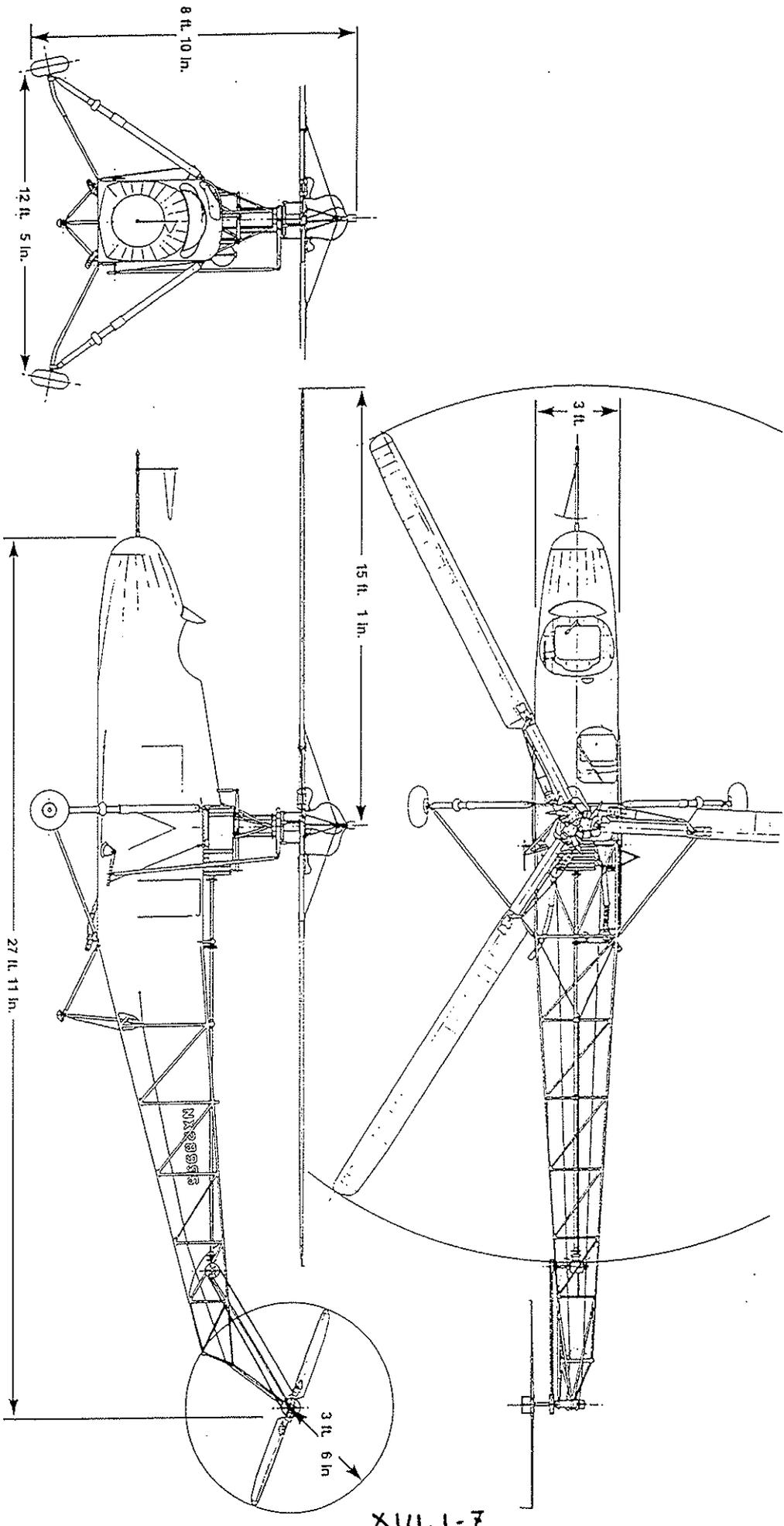
The VS-300 continued to fly through 1942 and 1943, primarily testing a variety of rotor systems and minor refinements that were being incorporated in the XR-4. In addition it was flown by a number of aviation personalities besides Igor Sikorsky. The list includes names such as Colonel H. F. Gregory, U.S. Army Air Corps, Charles "Les" Morris and D. D. "Jimmy" Viner, both pioneering helicopter test pilots, as well as Charles Lindbergh, who was an early supporter of the helicopter.

The VS-300 made its final flight on October 6th, 1943, when Igor Sikorsky flew it for a few minutes in front of Henry Ford and several thousand invited guests, landed and handed it over to the Ford Museum in Dearborn, Michigan, where it rests today.

During its interesting life, the VS-300 went through eighteen major reworks, several hundred minor changes and survived two major crashes. In four years, it logged just over 103 hours, and 35 minutes of actual flight time, most of it with Igor Sikorsky at the controls.

However, in those first two years, the VS-300 and its pilot refined a configuration that many had considered to be impractical, if not impossible. With typical modesty, Igor Sikorsky never claimed to be the inventor of the first successful helicopter, but rather a contributor to an international effort stretching back to Cornu and Breguet. Still, aviation historians agree that Sikorsky was the father of the single main rotor plus anti-torque rotor configuration, a scheme which continues to dominate the helicopter world today, fifty years after the pioneering flights of the VS-300.

# VS-300 GENERAL DIMENSIONS



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