The Vought XF5U ‘Flying Flapjack’

On the 25th of March 2010, the evening edition of the NOS news offered its viewers a glimpse at the future of aircraft design: the Zero Emission Flying Testbed. A blended wing body design created as part of the CleanEra project at the TU Delft. And our faculty isn’t the only one researching flying wings, take for example the Boeing Phantom Works X-48B blended wing body research aircraft. These new flying wing designs promise an increase in lift, a decrease in drag and better structural strength over current aircraft designs. But this shape is not as new as one may think. This article will take a look at some of the key features of blended wing bodies and flying wings by looking at a nearly forgotten prototype for a US Navy fighter plane: The Vought XF5U, better known as ‘The Flying Flapjack’.

AN UNORTHODOX CONCEPT
In 1933 the National Advisory Committee for Aeronautics (NACA) held an internal design competition in which employees were encouraged to come up with concepts for personal air transportation. Charles Horton Zimmerman, one of the youngest engineers working in their wind tunnels came up with an unusual design. He entered the competition with a small disc-shaped aircraft where the entire body acted as a wing. Fitted with two propellers at the front, he stated that that this design would be almost incapable of stalling, capable of taking off at steep angles of attack and low speeds, able to fly at high speeds and to land on short runways. His idea won the competition, but was deemed ‘too advanced’ to be pursued.

TOO ADVANCED FOR ITS TIME
What made it so advanced that even today we are still researching similar concepts? Flying wings promise a lot of advantages as already stated, but also come with some significant built-in downsides. The most major of these is in the field of induced drag: when air flows around the curvature of an airfoil you get two different pressure gradients, low pressure on the upper surface and high pressure on the lower. This creates lift by effectively pulling/pushing the plane upwards. But these pressure gradients create an additional effect at the wingtips. This is due to the pressure gradients meeting and the air pressure trying to equalize the difference by flowing around the wingtip. This results in a strong airflow curling around the wingtip, creating a vortex that significantly increases drag.

The predominant design strategy to counteract this unwanted effect is to build wings with a high aspect ratio. High aspect ratio wings are extremely long and slender wings. They try to approximate a theoretical wing with infinite length, therefore having no wingtips for the air to curl around. Zimmerman’s concept of a flying disk can be compared to an extremely short and stubby wing, with a very high induced drag coefficient. His solution was to install two massive propellers at the front edges of the flying disk and let them rotate in the opposite direction from the airflow curling itself around the edge. By negating the effect of induced drag, what remains is a small and nimble aircraft, with a light structure which is also strong, and one that produces a lot of lift due to its large lifting surface.

PROTOTYPES, WIND TUNNEL TESTS AND CRASHES
Undeterred by NACA’s refusal to invest in his idea, Zimmerman began building scale models in his spare time. In 1937, Zimmerman began working for Chance Vought Aircraft, an aircraft building com-
pany originally founded by one of the main engineers from the Wright company. There he was allowed to produce an electrically powered model called the V-162. This version contained no horizontal stabilizers, but most of the aft section of the disc could be hinged as a control surface, a concept he called the elevator. After applying for a patent for his design in 1938, Zimmerman sent a blueprint of his idea to the US Navy in March 1939. The navy was looking for a new aircraft that could take off from the short runway of an aircraft carrier, small enough to fit into the cargo hold and fast enough to compete with enemy fighters, and saw potential in his design. Within a month they had contacted NACA and Chance Vought and insisted that they further developed the concept. In October 1939 his employers at Chance Vought green-lighted the construction of the first scale model. These new prototypes became known as the V-173 (Figure 1). Wind tunnel tests showed that the concept had promise, but that the elevator design gave serious stability issues. The elevators were scrapped from the design and more conventional horizontal stabilizers were introduced.

After these tests, construction began on the full scale version of the V-173. The prototype had a wingspan of only seven meters but a wing surface of nearly forty square meters, the entire body was in the form of a symmetrical NACA 0015 airfoil and it was quickly dubbed ‘The Flying Flapjack’ by the engineers working on it. Built entirely out of wood covered with fabric, the entire aircraft weighed little more than 1,000 kilograms, making it light enough to be powered by two eighty horsepower air-cooled Continental engines.

At the hands of experienced test pilot Boone T. Guyton the V-173 undertook its thirteen minute maiden flight on the 23rd of November 1942. The concept proved successful; it was small, agile and was reported as being able to fly as slow as 64kph and as fast as 684kph. Much better than the usual four-to-one ratio between take-off and top speeds.

Testing a new design is of course a risky business and during the 131 hours they spent flight testing, the V-173 had its share of crashes. On one occasion, the V-173 got caught in strong winds and was forced to make an emergency landing on Daytona beach. The test pilot managed to reduce the aircraft’s speed down to near stall speed and landed in the sand, but was startled to find two sunbathers in his way. By locking his brakes and making a sharp sudden turn he managed to avoid the sunbathers, but flipped the plane in the process. Most aircraft would be seriously damaged by this, but in this case the flying wing design proved so strong that, aside from some snapped propellers, the plane and its test pilot were virtually unharmed.

THE VOUGHT XFSU
Seeing the concept proven in the V-173 the Navy ordered the construction of a full-powered navy fighter version. Designated the XFSU, it would be nearly identical to the V-173 in size and plan form. But built entirely out of aluminum it weighed six times as much, so to compensate for this they powered it with two Pratt & Whitney R-2000-7 radial engines, each supplying nearly 1350hp. The top speed was calculated to be in excess of eight hundred kilometers per hour, with a range of more than 1,600 kilometers. Intended as a fighter it was equipped with either six machine guns or two hundred-pound bombs.

Two prototypes of the XFSU were built in 1946. But by this time the project was long overdue and over budget. Add to that the rise of jet powered fighters that could outperform the XFSU by the sheer amounts of horsepower they had available, and it is no wonder that the Navy was forced to pull the plug on the 17th of March 1947, before the XFSU ever got the chance to fly. The V-173 prototype was transferred to the Smithsonian to be displayed as part of their exhibition, but the XFSUs were destined to be destroyed. Here, once again, Zimmerman’s design proved so structurally sound that they had to employ a wrecking ball to take them apart.

IN CONCLUSION
The new designs for the future of aviation such as the Zero Emission Flying Testbed or the X-48B may not be as futuristic as they seem, and hopefully this short trip through history has shown that they are indeed worth pursuing. Zimmerman was definitely ahead of the game, now is the time to start implementing his ideas.

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