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FLYING WITHOUT DYING

THE FUTURE OF WINGSUIT DESIGN

BY MARIA FERGUSON

Wingsuit flying is an extreme sport practiced by veteran skydivers and BASE jumpers. From 1930 to the 1960s, the attempt to create a functional wingsuit killed 96% of pioneers attempting to realize the dream of human flight. Today, hundreds fly in wingsuits, but flying remains a dangerous sport left to the select few.

We have the power to change that.

Achieving the Impossible

As a species, human beings have always been curious. From utilizing the potential of fire and ore to harnessing the power of electricity, we've poked at nature with inquisitive fingers until it bent to our will. We fly among the stars. We dive into the depths of the sea. We always push to find the next new frontier and make the next great discovery.

As we achieve some dreams, we forget about others. A century ago, we weren't sure human flight was possible. Today, thousands of people fly in commercial aircraft every day. But did we really achieve the dream of human flight?

I've flown in more commercial planes than I can count. I've flown in a see-through glider. I've ridden huge roller coasters and giant amusement park swings. I've even skydived. And you know what?

It's not enough.

Since I was a girl, I have wanted to fly like a bird. Independent, free, unrestrained, soaring through the clouds on my own power. I asked my parents why birds could fly and I couldn't. They told me humans are too heavy—birds have hollow bones, so their wings are powerful enough to lift their light bodies up into the air. I still remember that feeling of obstinate, childish frustration. Surely there had to be a way around this. Could I hollow out my bones, too? Lose a ton of weight? Drink some Willy Wonka bubble juice? There had to be *something*.

About eighteen years later, I finally found my answer in the sport of wingsuit flying and the study of aerodynamics.

What is Wingsuit Flying?

The sport of wingsuit flying takes skydiving and BASE (Building, Antenna, Span, and Earth) jumping to a new level. Skydivers and BASE jumpers jump out of planes or off tall objects, free fall, and pull a parachute before they get too close to the ground. Wingsuit flyers, on the other hand, wear suits that allow them to glide through the air before they eventually lose altitude and pull their parachutes. The flying squirrel-like suits are made of highly durable fabric and have two wings, one below the arms and one between the legs, creating a flat surface to make gliding possible [1].

The history of wingsuit flying is as brief as the lives of the first wingsuit pioneers. French tailor Franz Reichelt first took the plunge in a hand-sewn "parachute suit" in 1912—and fell 200 feet from the first platform of the Eiffel Tower straight to his death [2].

Franz Reichelt, 1912 [2]

Reichelt's failure did little to discourage others from trying to achieve the dream of human flight. From 1930 to the early 1960s, 72 of 75 aspiring "bird men" died in the attempt. The first viable wingsuit was developed—along with modern skydiving technique—by Leo Valentin in the 1940s. Valentin made huge strides forward in the quest for unassisted human flight, but in 1956, while testing a pair of large, rigid wings, his wings caught the air from the departing plane. He deployed his parachute, but it twisted and tangled in the lines, and he perished like his predecessors. [3]

In the 1990s, a man named Patrick de Gayardon tried something new. Using sturdy parachute fabric, he fashioned a flexible wingsuit with two wings, one under the arms and one between the legs, with vents to allow the suit to inflate. This allowed him to glide through the air like a bird for about a minute until he lost enough altitude to pull his parachute. He was known as the "bird man" and inspired awe among the skydiving community and the world at large until his tragic death in a skydiving accident. [3]

Patrick de Gayardon, 1990s [4]

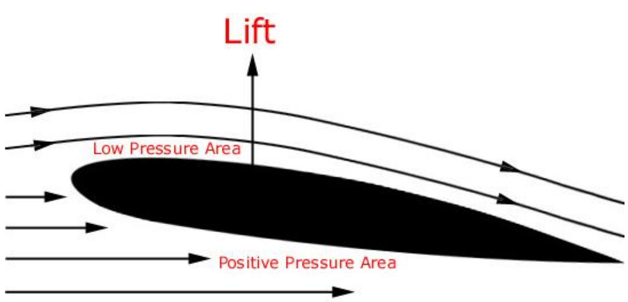
Since de Gayardon's death, several companies have imitated his wingsuit design and made wingsuits available for public purchase. In fact, the first wingsuit company, established in 1999, was named "Birdman" in de Gayardon's honor [5]. The sport is still small—Robert Pecnik, founder of Phoenix-Fly Design and co-founder of Birdman International, estimated in 2010 that there might be 600 flyers worldwide. About 40 or 50 of these are proximity flyers who BASE jump from cliffs and buildings and fly in close proximity to the ground [6].

To date, the vast majority of wingsuit development has been completed with the "guess and check" method. Unfortunately, many daredevils have guessed wrong. More recently, however, universities and engineers have conducted experiments to inspect the aerodynamics of wingsuit flight, and it is studies like these that will once again revolutionize wingsuit flight.

Aerodynamics of Wingsuit Flight

At its heart, the basic concepts of aerodynamics are simple. Lift makes you go up. Weight makes you go down. Thrust propels you forward. Drag resists forward motion [1]. But making a heavy object—especially one without much of a wingspan—fly through the air is far more complex.

The first step to optimizing lift is to create an airfoil, shaped like a symmetrical tear drop. As dictated by Bernoulli's Principle, the higher velocity of the air over the top of the airfoil creates lower pressure above the airfoil and higher pressure below it, generating lift [7].



Airplane wings are airfoil-shaped. The human body? Not so much. That's where the wingsuit comes in.

The critical difference between wingsuit flying and skydiving is that the wingsuit converts most of the vertical velocity into horizontal motion. While skydivers freefall up to 120 mph vertically and 30 to 60 mph horizontally, wingsuit flyers fly only 50 to 60 mph vertically and about 70 to 90 mph horizontally, depending on the wingsuit and the flyer's position [1]. This is possible because the wingsuit creates lift, which counteracts the weight of the flyer. As the flyer shoots forward, small adjustments to their body position drastically affect their trajectory. This makes steering intuitive, but the wingsuit still suffers from inefficiency in lateral flight [8]—the high forward velocity makes it difficult to make sharp turns without sacrificing stability.

The true genius in de Gayardon's vented fabric suit is the use of airflow to inflate the wings. Wingsuit designers such as Tony Uragallo shape the wingsuit so that the wings actually inflate in the form of an airfoil, generating greater lift. While many wingsuits provide glide ratios of 2 vertical miles for every horizontal mile lost in altitude, the Tony Uragallo design provides a glide ratio of 3.6 to 1. Simply by taking advantage of the airfoil shape, flyers can dive to gain speed and actually swoop upward, gaining altitude. [9]

Another aerodynamic consideration is the effect of turbulent flow—all the strange eddies that emerge when high velocity air encounters an object—on a wingsuit flyer, since stability is so important. The weather can affect flight as well: variations in temperature, humidity, or gusts of wind can suddenly change the air pressure and trajectory of the flight. In the case of proximity flying, pinpoint accuracy is critical. A slight miscalculation or gust of wind can make the difference between clearing a ledge by a few feet, or crashing into it at horizontal speeds in excess of 60 mph.

Phugoids are another example of instability, and arise if any sort of thrust is introduced to the wingsuit flight, such as adding small jet engines to the flyer's feet (although this system has been attempted only in simulations) [8]. Phugoid mode instability basically means that the object in flight pitches up and down [10], which can be a slight nuisance for an airplane pilot, but a death sentence for a wingsuit flyer.

Modern Wingsuit Design

Most modern wingsuits have the same basic features: flexible, durable fabric such as extra-sturdy nylon, air inlets and outlets, tougher leading edges, and various features for comfort and safety, such as reinforced booties and cut-away arms [11]. The wings are designed to create an effective airfoil, although some companies emphasize this more than others.

The dimensions of the wingsuit are custom made to fit each person, and stay within the limitations of the human body. The wingspan is the same as the flyers' wingspan and the only rigid frame is the body of the flyer. A larger wingspan runs the risk of catching a gust of wind or the draft of the plane and spiraling out of control—the cause of Leo Valentin's death. The small wingspan is also due to the limitations of human strength. Too great a wingspan will put too much strain on the muscles and force the flyer to play a losing game of tug-of-war against the wind.

Another less scientific but just as compelling reason to keep the wingsuit small and flexible is the desire for "natural" flight. Wingsuit flying is truly the embodiment of the dream of human flight, and to supplement the suit with a bulky framework or roaring jet engine is to compromise the intimacy of the flight.

Possible Design Improvements

In recent years, several groups have recognized the need to study wingsuit flight scientifically. A 2010 MIT study used a mannequin in a wind tunnel to measure the performance of a wingsuit with a third, forward wing and compare it to the traditional wingsuit. The extra wing was added above the arms and behind the head to increase the aspect ratio, or the ratio of the wingspan squared to the wing area. They found that the additional wing generated both higher lift and drag, which meant that the redesigned wingsuit would have a longer flight time, but shorter flight range. [12] Testing and modifications such as this are a prime example of how scientific study could drastically improve modern wingsuits. Although the MIT design might never be implemented due to the shortened range, its slower horizontal velocity could be a step in the direction of achieving a parachute-less landing [12], another dream of wingsuit flyers.

Redesigned Wingsuit with Forward Wing, MIT [12]

Wingsuit designer Maria von Egidy is currently researching the problem of landing without a parachute. She aims to create a larger suit with a higher glide ratio and more stable airfoil that has the ability to flare before touchdown, i.e., maximize lift and minimize speed just before landing. The relatively small wingspan to weight ratio makes this a difficult and dangerous endeavor, but the idea shows promise. [13]

Even more extreme ideas have been proposed, such as Geoffrey Robson and Raffaello D'Andrea's proposal to create a jet-powered wingsuit. In their 2010 American Institute of Aeronautics and Astronautics study, they found that phugoid mode instability and inefficiency in lateral flight were the main obstacles to the feasibility of affixing thrusters to a wingsuit flyer's feet. They suggested that using computer systems to map body position and create automatic thrust vectoring might provide a solution to these problems. [8]

Before his untimely death, Robson in particular was optimistic that with a sufficiently sophisticated computer system, a jet-powered wingsuit could be feasible. If a sufficiently stable wingsuit design was paired with a vectored-thrust system, this would not only be a huge leap forward in making propulsion a reality for wingsuit flyers, but would also improve the safety of ordinary wingsuit flying. A more stable wingsuit would reduce the fatality rate of two dozen per year and climbing [14].

What Next?

The scientific community has begun to take interest in the wingsuit design problem, but even so, rigorous aerodynamic calculations and laboratory experiments are more the exception than the rule. There are many great ideas out there, but the wingsuit design community needs better technology and investment—from corporate investors as well as scientists and engineers.

Even within this brief overview, there are many avenues to explore when it comes to wingsuit design improvements. To improve wingsuit flight, we might look into making the suit a more effective airfoil, adjusting the angles of the arms and legs angles to the torso, adding additional wing surface area, or even using cutaway rigid wings. When it comes to landing without a parachute, we might use a small drag chute, squirrel-like pouched chute, wing flaps, or hang glider-like flaring systems. The possibilities are endless.

If there's anything we humans are good at, it's using our brains to overcome the next big obstacle. The modern wingsuit is only twenty years old and wingsuit flying is still in its infancy. Like the modern airplane, the wingsuit only needs more research and investment to improve safety and functionality. As of now, wingsuit flying might seem like an extreme sport reserved for the insane, but in a few years it could become as popular as skydiving, and in a few decades, as popular as skiing or rock climbing. The technology could also be developed for military applications. Just as the parachute was a game-changer in military combat, a high-speed, navigable exit system would provide enormous tactical advantage, especially with a parachute-less landing.

We humans are dense. We have heavy bones and heavy muscles. But we also have brains, and that is our greatest advantage.

We *can* fly like birds. We just need to spread our wings.

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