

Air and Space this Week

Item of the Week

OTTO LILIENTHAL

“Sacrifices Must Be Made”

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The Wright Brothers were first to build a powered airplane, but they were not the first to fly. The credit for that usually falls to Otto Lilienthal, who began experimenting with gliders in the late 1860s, and developed, built, and flew gliders for the rest of his life. His success caused an international sensation, and he significantly inspired the Wrights and their competitors.

THE DREAM OF FLIGHT

People have dreamed of flight for millennia. Stories like that of Daedalus and Icarus, and accomplishments like the balloons of the Montgolfiers only increased the general interest. Others, inspired by birds perhaps, tried all kinds of very goofy contraptions, some with dire consequences (e.g. [here](#)). And one person took an experimental approach that inspired many to follow.

Otto Lilienthal was born on May 23, 1848, **175 years ago** this week, in Germany. He developed an interest in how things work, and in ornithology, as a young man. His interest led him to a degree in mechanical engineering from the predecessor to Berlin University, where his combined interests led him to experiment with human flight, building unsuccessful wooden wings with his brother Gustav. His studies had to wait after graduation; he served a stint in the Franco-Prussian War. His desire for flight was unabated; he could often see and admire hot air balloons flying over Paris.

Lilienthal secured a position as an engineer in Berlin after military service. He also continued an aggressive aviation research schedule and found time to become an expert in the mechanics of the flight of birds. On top of that, he was a very creative engineer, inventing a diverse set of 25 patent-worthy items (only four of which were related to aviation). He was a hard-driving, hard-working kind of person, often spurring his team’s performance with a statement that “sacrifices must be made” whenever something went wrong. He became an expert on steam engines, and developed a safer and better type of boiler. It was safer and more efficient than any previous boiler design, so Lilienthal opened an engine factory in 1883 to build them, and prospered greatly.

Financial success gave Lilienthal the time and money needed for him to continue the pursuit of his dreams of flight. He wrote and published a definitive book in 1889, *Bird Flight as the Basis of Aviation*, detailing the characteristics of different types of bird wings, the physics behind how the wings worked, and how that information might be applied to human flight.

Lilienthal returned to building gliders in 1891. This particular model of wings involved an A-shape supporting an overhead wing, not unlike some of the first hang gliders of 80 years later. Nylon would not be invented for decades; Lilienthal used cotton fabric on a frame of willow. He recognized the need for the wing to be curved in cross section, not flat, a major advance (even though, as we will see, he was not the first to realize the importance of wing shape). His 1891 glider was relatively stable in flight, and Lilienthal managed to glide up to 80 feet with it. He continued to make improvements in the design, and within two years came up with a glider that could fly over 1000 feet.

Not all of Lilienthal's ideas were practical. The weight of his gliders was one of the primary limiting factors on their performance, but there was little room for improvement given the materials at hand. He had learned enough to know that controlling flight would be complicated, too. His gliders relied on the pilot shifting their weight to steer the glider's path. That put a strict upper limit to the size gliders of his type could reach; as they got bigger and heavier, the position of the pilot would have less and less effect on the flight path.

Lilienthal created a basic glider design in 1894 that he could build in quantity and sell to enthusiasts world-wide. He would make a number of improvements in the ensuing years, coming up with a total of 18 distinctly-different glider models. He was definitely a "hands-on" type of engineer, and suffered a number of minor injuries during the flight testing of his gliders.

INSPIRATION AND TIMING

Lilienthal's gliding attracted a lot of attention, including that of some of the famous early photographers of that period. Newspapers and magazines used those pictures in breathless stories of the brave German challenging the birds for flight, exciting their readers, some of whom would be inspired to experiment with flight on their own, especially with the development of engines that were powerful enough and light enough to possibly propel a heavier-than-air craft. The Wright Brothers weren't the only ones so motivated; people came great distances to consult with Lilienthal on matters relating to aviation, including Octave Chanute, Smithsonian Secretary Samuel Pierpont Langley, and many other noteworthy experimenters.

Lilienthal and the Wrights were much alike. The both used trial-and-error in building the various models of the gliders, learning much about practical aeronautics along the way. They did not take a theoretical approach to the physics involved in engineering and moving air.

And they weren't the first to fly.

When I was at NASA HQ, the watch phrase was "Science isn't finished until it's shared" (thank you, KE!). The same could be said of early airplane research.

Englishman George Cayley, working decades before Lilienthal, took a theoretical approach to flight. Alas, much of his fundamental work was unknown for years, and I could find no evidence that Lilienthal was even aware of Cayley's research. But Cayley was not able to share his results widely, and did not have pictures of his glider in action, therefore he did not fire the imagination of the public as Lilienthal's photography pals did.

I have mentioned the wonderful Centennial of Flight website on previous occasions in Air and Space this Week, and I found an archived piece of it about Cayley ([here](#)). And that led me to the CoF's Lilienthal [page](#). Check 'em out!

Cayley was born in 1773, a century before Lilienthal began working with gliders. He correctly identified the four basic forces affecting flight: gravity, lift, thrust, and drag. He was the first to build a human-carrying glider. He was the first to understand that the shape of a wing can produce lift, and first to understand the importance of the center of gravity and the center of pressure, and their effect on flight stability. He built and tested many models, too, and by 1799 he designed the first "modern" aircraft, with wings, fuselage, and tail that had both elevators and a rudder. He could demonstrate that sustained flight, not just gliding, required a then-nonexistent propulsion force. He even published his research in 1809, but it was in an obscure publication not seen by many.

I might thus claim, as many do, that Cayley should be considered the "Father of Flight," based on Cayley's glider flights, but the Montolfiers would object, as would Lilienthal fans. So we have: First to Fly (Montgolfiers), First to make a glider that carried a human (Cayley), First to popularize the concept of flight (Lilienthal), and Inventors of the First Airplane (Wrights).

LILIENTHAL AGAIN

Lilienthal continued to experiment with his glider designs, eventually racking up over 2000 flights with a cumulative flying time of about five hours. He even built his own hill, Fliegeberg, from which he could make flights into the wind (increasing lift) regardless of the direction from which the wind came.

When Lilienthal didn't use Fliegeberg for tests, his favorite alternative was the Rhinow Hills, not far from Berlin. August 9, 1896 dawned with the offer of pleasant gliding weather, so Lilienthal set out for the Rhinows with his glider and mechanic for a day of gliding and testing. His first three glides went very well, on the order of 250 meters each. But a gust of wind caught him during his fourth glide, pitching the nose of his glider up, causing it to stall and nose down. Lilienthal could not shift his weight back far enough quick enough with the glider's nose-down attitude, and he fell from the sky, about 15 meters.

The glider was smashed in the fall, and Lilienthal suffered a fracture of his third cervical vertebra. He was briefly knocked out in the impact, but regained his senses somewhat. Mechanic Paul Beylich took him by horse-drawn carriage to the nearest doctor, in the nearby town of Stölln; with Lilienthal losing consciousness on the way. His injuries required better facilities so he was transported by cargo train to Berlin and got to one of the best medical

facilities there the next morning. He died there a few hours after his arrival, 36 hours after the crash.

Years after Otto's death, his sister would relate that his final words were "Sacrifices Must Be Made." That actually seems unlikely, but it is true that Otto often expressed that same sympathy. A [monument](#) to Lilienthal was installed on [Fliegeberg](#), and there is a [museum](#) in Berlin dedicated to Lilienthal and his work.

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