

Hang Gliding: Science in the Clouds

ERIC PERLMAN

When crazed monks and princes leaped from their castles and cathedrals in the Middle Ages gripping undersized wings made of sticks and cloth, they met with little success. Long on faith but short on aerodynamics, the few "tower jumpers" who survived were carted away with no desire to try again.

Today's hang-glider pilots have surpassed the most goggle-eyed dreams of their tower-jumping forebears. From New Hampshire to New Zealand on any day when the winds are right, thousands of pilots assemble their multicolored wings, clip in their flying harnesses, and step to the edges of cliffs, dunes, and mountain peaks. A quick charge into the wind and these modern-day Daedaluses rise into the sky and begin their search for elevator updrafts that can take them miles from Earth.

Like sailboats, hang gliders come in an array of shapes and sizes and perform differently in different winds. In the unforgiving world of the air, function follows form-exactly. The underlying principles of hang-gliding aerodynamics are the same as for any other aircraft. The wing cleaves the air, causing it to pass both over and under the wing's surfaces. Because of the curvature of **the upper surface**, air passing over the wing must travel farther and move faster than air passing under the wing. This lowers pressure above the wing relative to that below it, creating lift.

The swept-back wings of an F-16 are designed to achieve maximum performance at supersonic speeds. The billowing belly of a kite-like, diamond-shaped Rogallo hang glider performs best at nineteen miles per hour, with a glide ratio of four to one. That is, for every four feet of horizontal flight in stable air, the glider will sink one foot. Modern hang gliders, which cost around \$2,000, offer glide ratios up to eleven to one.

The greatest obstacles to flight and lift are gravity and drag. The leading edge of the wing, the pilot, and other surfaces on the glider impede flight by disturbing the air flowing over the glider. The air also forms tiny eddies at the wing's tips and edge, creating more drag and decreasing lift. Because longer wings reduce this turbulence, some high-performance hang gliders now have wingspans greater than thirty feet.

The original version of the modern hang glider was patented in 1951 by an American, Francis M. Rogallo. The National Aeronautics and Space Administration worked extensively with the Rogallo wing in the 1950s and 1960s in its search for a steerable, gliding parachute for manned and unmanned space capsules. Though the Rogallo design never made it into space, word of the wing reached the public.

Early hang-gliding enthusiasts built their wings out of polyethylene and bamboo. These so-called ground skimmers quickly gave way to gliders constructed with Dacron sails and aircraft-grade aluminum frames. With safer, stronger wings, hang-glider pilots of the early 1970s went higher and farther, flying off mountains and soaring on the steady updrafts atop ocean-facing cliffs such as those at La Jolla's Torrey Pines, Oahu's Pali Cliffs, and San Francisco's Fort Funston. This whetted the pilots' hungers still more, and they began to tinker with the basic Rogallo design, lengthening the wings and tightening the sail for better lift. Some scrapped the original shape of the Rogallo altogether and returned to the biplane glider designs of the Wright brothers or the nineteenth century ribbed wings and tails of Otto Lilienthal, whose last words before dying from a hang-glider crash were, "Sacrifices must be made."

Sacrifices were made in the 1970s as well. As fatalities and injuries increased every year, hang gliding became known as "the killer sport." Then in the late 1970s hang-glider manufacturers started using professional pilots to test-fly the gliders first. The industry set manufacturing guidelines, pilots were given flying ratings, and new safety consciousness arose, with the result that despite an enormous boom in the sport's popularity, deaths from hang gliding appear to be waning.

Meanwhile, successions of design changes have given hang gliders more speed, maneuverability, and lift. Hang gliders owe much of their expanded range and safety to the advent of the double-surface sail. This innovation, shaped like the one-layered wing it replaced, presents a typical, cambered airfoil to the wind, but at high wind or flying speeds the two layers compress, resulting in less drag and greater stability. Soaring at low air speeds, the sail billows, making a thicker airfoil that provides a higher glide ratio.

Although the international hang-gliding record committee is located in Paris, most official world records are set in the Owens Valley of California on the eastern side of the Sierra Nevada range. Robert Thompson has flown 139.8 miles point to point. New Zealand's Ian Kibblewhite flew 13,694 feet above his launch point. Though not sanctioned in Paris, the world record for duration aloft was set in 1982 when Jim Will spent a record 24 hours and 32 minutes gliding over the Hawaiian island of Oahu.

These world-class glider pilots fly so high by looking low. Micrometeorology, the intricacies of wind circulation, air density, updrafts, downdrafts, and turbulence within the immediate flying region is as crucial to a hang-glider pilot as surf to a surfer. A hang-glider pilot can read the air to a large extent from the landscape beneath it. A dry, grassy field in the sun warms quickly, heats the air, and causes updrafts. A forest absorbs heat, making for downdrafts. A cliff standing in the face of a prevailing wind offers steady, soarable updrafts, but the top or lee side of the cliff is the lair of the deadly "rotor," a powerful, circular downdraft that can slam a glider straight into the ground.

Like water following the contours of a stream bed, air conforms to the surface features of the earth. A gap in a cliff or a cool deep canyon can cause downdraft or turbulence. Mountain peaks can set up a wave pattern in air similar to waves downstream from a submerged rock in water. If a mountain "downstream" from the wind wave is in the right position to harmonize with the wavelength of the wind that has been set by mountains further upwind, a steady updraft forms and holds on

the windward side of the peak, offering a soarable wave that can reach higher than 50,000 feet. Since sailplanes have soared to 46,000 feet, hang gliders will surely continue their rise into the stratosphere. The tower jumpers would have been pleased.

