THE REBIRTH OF HANG GLIDING AND ULTRALIGHT SPORT AVIATION

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INTRODUCTION

Ultralight aircraft provide thousands of participants an inexpensive avenue to fly recreationally. The aircraft are manufactured in a viable industry using technology developed to optimize performance at low cost.

Many pioneering aircraft of the 1890-1930 timeframe were hang gliders and ultralight aircraft. Examples include the hang gliders of Otto Lilienthal and Octave Chanute, the famous gliders of the Wright brothers, and Santos Dumont's famous Demoisille ultralight airplane of 1909. Powered flight rapidly evolved into heavier, faster, and more sophisticated aircraft to serve the multitude of military and commercial roles they do today. In the early 1970's a rebirth of sorts occurred with the adaptation of Francis Rogallo's flexible wing into a viable weight-shift controlled hang glider. These "Standard Rogallo" wings offered recreational flight to an ordinary person at an affordable price, though with some dangerous flight characteristics. Hang gliding as a sport evolved rapidly during the 1970's and 1980's with the advent of better, safer gliders and improved pilot skills. In the USA, the FAA allowed self-regulation by not requiring licensing of pilots or certification of gliders. The United States Hang Gliding Association (USHGA) standardizes training, rates pilots, and promotes the sport. Hang gliders are currently certified privately through limited testing to Hang Glider Manufacturing Association (HGMA) standards.

In the mid 1970's pilots began adding small two-cycle engines to hang gliders, and the rebirth of ultralight aviation began in earnest. A burst of creativity resulted in many new designs, many with dangerous flight characteristics. Several groups offered training and certification of pilots. Safer designs evolved into several basic types, including conventional looking designs, trikes, and powered parachutes.

Paragliding began during the 1980's with the advent of foot-launched gliding parachute-like aircraft. Powered paragliders soon followed. Likewise, several foot-launched sailplane designs also evolved during the 1980's, and ultralight sailplanes have emerged as another new, exciting sport aviation discipline. Current hang gliding technology includes rigid winged designs offering greatly improved performance.

DEFINITIONS

It is useful to define the various types of ultralight aircraft to avoid confusion (Figure 1). In the USA, the definition of ultralight aircraft is provided by the Federal Aviation Regulations, FAR Part 103 (Reference 1). These regulations define an unpowered ultralight aircraft as one that weights less than 155 lbs. empty, with 254 lbs. allowed for powered ultralights. Stall speed must be less than 24 kts. and maximum level flight speed may not exceed 55 kts. There are other criteria for applicability that are found in Reference 1.

A hang glider is an unpowered ultralight designed to take off and land on the pilot's feet, and is often controlled by weight-shift of the pilot's body rather than aerodynamic controls. Usually the pilot is suspended prone below the glider in a comfortable harness. 1970's vintage hang gliders were called Rogallos and had a wing structure that had no supporting ribs and a flexible, single surfaced airfoil. These evolved into flex-wing hang gliders used today that feature a double-surfaced airfoil with ribs defining the wing's airfoil shape. Rigid wing hang gliders have structure more like conventional aircraft, usually have aerodynamic controls, and may partially enclose the pilot. Ultralight sailplanes are a further evolution but are usually too heavy to be foot-launched.

A paraglider is a foot-launched glider with no rigid structure, and typically resembles a high-performance parachute. Small engines power some paragliders. Another flexible-winged ultralight is the powered parachute, where the pilot is seated rather than foot-launches. Other powered ultralights include trikes, which resemble hang gliders, and many conventional designs that are evolving into light airplanes.

CHRONOLOGY

Table 1 lists in chronological order the primary historical events in the development and rebirth of both unpowered and powered ultralight aircraft.

THE FIRST GLIDING PIONEERS

The first heavier than air gliding flight took place in 1849 when Sir George Cayley launched his coachman in a glider in England (Reference 2). In 1883 it was reported that John Montgomery flew a hang glider from the Otay Mesa, but no photographs exist of the flights. Successful balloon-

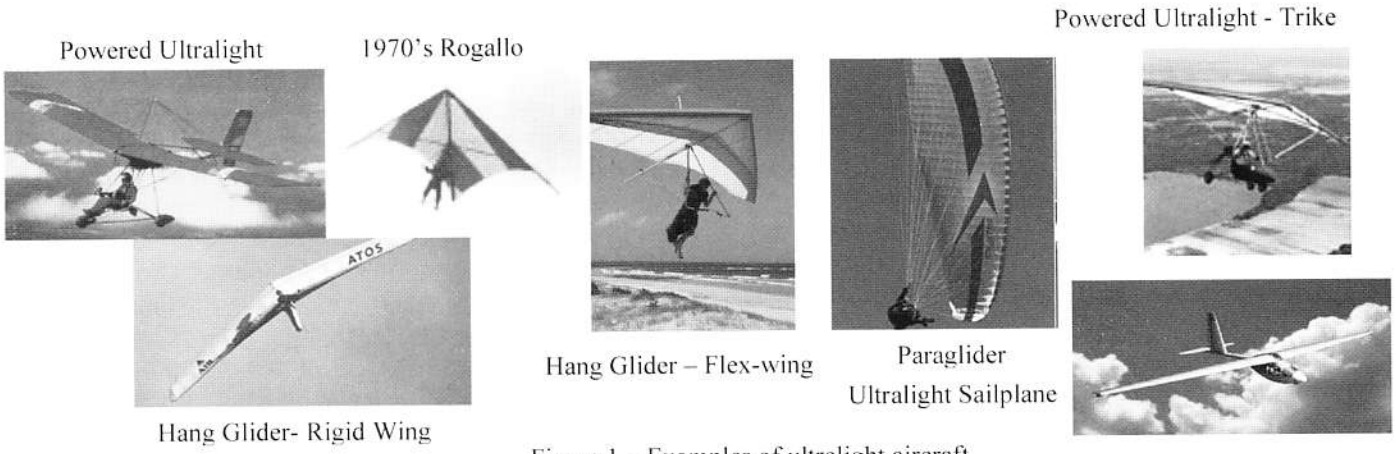

Figure 1 – Examples of ultralight aircraft

Table 1 -Timeline of Major Hang Gliding, Paragliding, and Ultralight Airplane Events

Year	Event
1849	Sir George Cayley, first human glides in heavier than air device of Cayley's design, England
1883	John Montgomery, first hang glider flight, San Diego, CA
1891-1896	Otto Lilienthal, first photographed and widely documented hang gliding flights, Germany
1896, August 10	Otto Lilienthal dies after crash of Aug 9, Germany
1895-1899	Percy Pilcher, hang gliding in Lilienthal-like monoplanes, Scotland
1896-1897	Octave Chanute and Augustus Herring's biplane glider flights, Gary, IN
1900-1903	Orville and Wilbur Wright, first aerodynamically controlled gliding flights, Kitty Hawk, NC
1903, Dec. 17	Wright bros, first powered, sustained, controlled heavier than air human flight, Kitty Hawk, NC
1904	Lavezzari's Rogallo-like hang glider flight, France
1905	John Montgomery (Ed Maloney as pilot), first balloon launched glider flights, Santa Clara, CA
1906, Sept. 13 & Oct. 23,	Alberto Santos-Dumont, First European powered flights with 14-Bis, France
1909	Alberto Santos-Dumont, Demoiselle ultralight flights, France
1909	Carl Bates publishes plans for Chanute-type glider in Popular Science, built by multitudes, USA
1911, Oct. 24	Orville and Wilbur Wright, first documented soaring flight of 9:45, Kitty Hawk, NC
1920-1922	First gliding competition, Rhoen, Germany
1923	Reinhold Platz, Sail wing ultralight glider, Netherlands
1920's & 30's	Many ultralight aircraft developed and flown in USA and Europe
1948	Francis and Gertrude Rogallo develop flexible wing concept using kites, VA
1951, Mar 20	Francis Rogallo US patent 2,546,078 granted for "flexible kite", VA
1955	Andi Mattalatta reportedly towed behind a water ski boat with Rogallo, Indonesia
1961, Dec. 30	Barry Palmer, First foot-launched Rogallo hang glider flight, CA
1963	John Dickenson, first control bar used with Rogallo hang glider, Australia
1966	David Barish develops and flies Sailwing, a primitive paraglider, VT and CA
1966	Barry Palmer, first foot-launched powered hang glider, CT
1967	Barry Palmer, first "trike" powered hang glider, FL
1969	Richard Miller develops and flies Bamboo Butterfly hang glider, CA
1971, May 23,	First modern hang gliding meet to honor Otto Lilienthal's birthday, Newport Beach, CA
1971, Sept. 6	Dave Kilbourne soars his Rogallo for 1 hr., 4 min., Mission Ridge, CA
1972	Resurgence of hang gliding widely reported by the media
1972	SCHGA formed, later becomes USHGA in Dec., 1973, CA
1975, March	USHGA pilot rating system implemented for hang gliding
1975	John Moody flies his Icarus II hang glider with a motor attached, WI
1978	Bill Bennett, first commercially available emergency parachute of hang glider, CA
Late 1970's	Ultralight aircraft begin to gain popularity, peaking in early 1980's
1980	UP Comet, first commercially successful double surfaced hang glider, CA
1982	FAR part 103 implemented, regulating ultralight flight in USA
late 1980's	Paragliding becomes popular world wide
1990's	Towing of hang gliders by vehicles and ultralights enables convenient flat land hang gliding
1997	Exxtacy available, first widely used, commercially successful rigid wing hang glider, Germany

launch flights of Montgomery's Santa Clara glider in 1905 later lent him credibility (Reference 3). Drawings of these early gliders are shown in Figure 2.

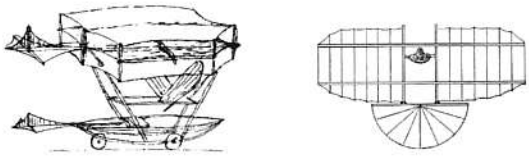

Figure 2 – 1849 Cayley glider (L) and 1883 Montgomery glider (R)

Otto Lilienthal captivated the world with the first widely publicized and photographed hang glider flights in Germany from 1891 until his untimely death on August 10, 1896. Several photos of his gliding experiments are shown in Figure 3 and more information is available in References 4 and 5.

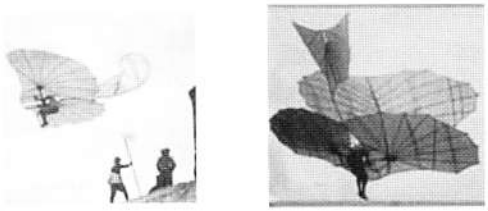

Figure 3 – Otto Lilienthal gliding flights

Octave Chanute was a successful civil engineer who sponsored gliding experiments of several designs in 1896 and 1897. The most successful design was the Chanute-Herring biplane glider with the author's 1996 replica shown in Figure 4. More information may be found in References 6 and 7.

Figure 4 – Replica of Chanute-Herring biplane of 1897

Percy Pilcher flew Lilienthal-like hang gliders of his own design in Scotland and England starting in 1895 and ending with his tragic death due to a structural failure in 1899. More Pilcher information is available in Reference 8.

The Wright brothers used gliders extensively to develop the airplane, though they were not hang gliders. The 1902 Wright glider was extremely significant because it was used to develop the multi-axis flight controls that enabled the Wright's powered, controlled flight of December 17, 1903. They also recorded the first sustained soaring flight of 9 minutes, 45 seconds on October 24, 1911. Photos of the Wright 1902 glider and the 1911 soaring flight are shown in Figure 5. References 9 to 13 contain an abundance of Wright history.

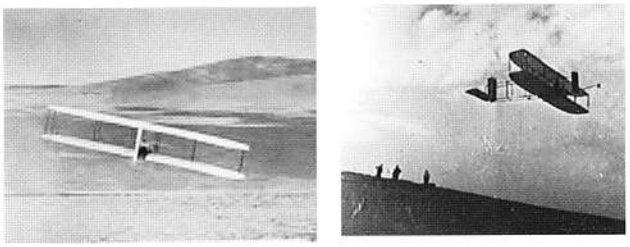

Figure 5 – Wright 1902 (L) and 1911 (R) gliders

UP TO WORLD WAR 2

With the invention of the airplane in 1903, gliding experiments declined and powered flight developed. John Montgomery continued gliding experiments until his untimely death in 1911, including the first balloon launched glider flights in 1905. These included flights of 15 minutes and glides from 4000 feet above the ground (Reference 3).

The first European powered flights were by Brazilian expatriate, Alberto Santos-Dumont in his 14-bis in September and October, 1906. Santos-Dumont created what could be described as the first ultralight airplane with his successful Demoiselle design of 1909. The reported empty weight of the original No. 19 Demoiselle was 123 lbs. A later version, the No. 20, was put into limited production. Figure 6 shows the Demoiselle and Reference 14 documents this series of designs.

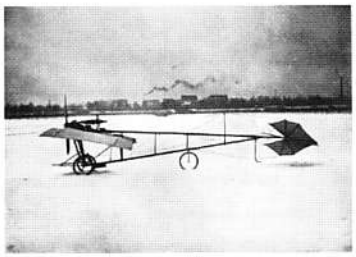

Figure 6 – Santos-Dumont Demoiselle, the first true ultralight airplane.

Some gliding experiments continued, with Carl Bates publishing the famous drawings of a 20 ft.-spanned Chanute-type biplane glider in 1909. In 1911, The Wright brothers set a gliding endurance record of 9:45 at Kitty Hawk (Figure 5). The armistice after World War 1 curtailed powered aviation in Germany but did allow gliding. The first gliding competition was held at Rhoen, Germany in 1920, and was won by Willi Pelzner in a biplane hang glider. Within a few years the glider designs advanced rapidly and the sport of soaring was born.

Several interesting gliders flew that embodied some of the principals later perfected by Francis and Gertrude Rogallo (Figure 8). One such example was a glider reportedly flown in 1904 in France by Mr. Lavezzari. Another was a sail wing glider flown by Reinhold Platz in 1923 in the Netherlands.

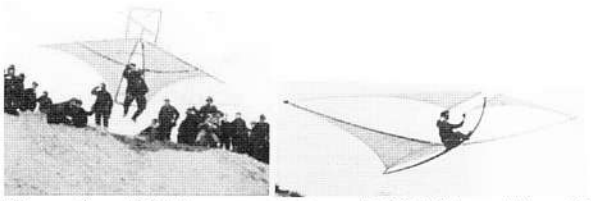

Figure 8 – 1904 Lavezzari(L) and 1923 Platz gliders(R)

Many light weight airplanes were developed in the 1920's and 1930's by home builders, who often also created their own engines as well. The ultralight-type aircraft were practically the only option for individuals who wished to fly but faced the harsh conditions of the post-war and Depression-era economies. One example of such an airplane was the DeHavilland DH-53 Hummingbird (Figure 7).

Figure 7 - DeHavilland DH-53 Hummingbird

THE REVIVAL OF HANG GLIDING

In 1948, Francis and Gertrude Rogallo started developing a flexible wing concept that eventually evolved into the popular hang gliders of the 1970's and paragliders of the 1980's. Rogallo worked as an engineer for the NACA but developed the idea on his own time with Gertrude's support (Figure 9). The idea was patented on March 20, 1951. During the space program, the US government researched the possibility of using this concept for re-entry of space vehicles, but that stopped once parachutes and ocean recovery were chosen instead. Rogallo was certain that, "One of these days we're going to make one of our kites large enough to lift a man." Rogallo retired to Kitty Hawk and later was able to fly hang gliders at nearby Jockey's Ridge, finally fulfilling his dream of personal flight. More information is available in References 15 and 16.

Figure 9 – Francis Rogallo and his kite (photo by Michael Henry, Ref. 16)

At least seven other individuals worked independently to develop the Rogallo concept into viable, personal aircraft. In 1955, Indonesian Major General Andi Mattalatta flew a Rogallo hang glider as a tow kite behind a boat (Reference 17). Gen. Mattalatta had to hold on to the glider and had no harness. In 1961, Thomas Purcell started work on a Rogallo glider towed behind a car. Purcell sat in a seat and later installed floats so the glider could be towed over water. On December 30, 1961, Barry Palmer performed the first foot-launched, non-towed hang glider flight in a Rogallo wing with a series of flights in California (Figure 10). He held on to a pair of struts and had no harness holding him to the glider. References 18 and 19 further document his work.

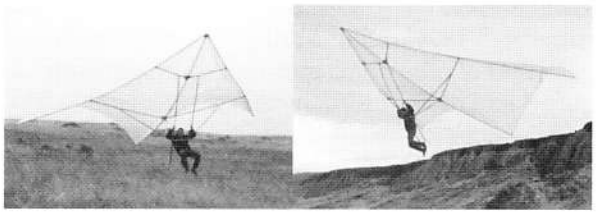

Figure 10 – Barry Palmer's 1961 Rogallo flights

In September, 1963, Australian John Dickenson developed a Rogallo glider with a control bar and a single hang point for the pilot. He successfully blended the elements that evolved into the Standard Rogallo hang glider (Figure 11 and Reference 20). Dickenson collaborated with Bill Moyes and Bill Bennett to develop the Ski Wing into a marketable product. Later, Bennett began water ski exhibition flights in the US and Moyes did the same in Australia. Bill Bennett attracted much attention by flying over the Statue of Liberty in 1969 (Figure 12).

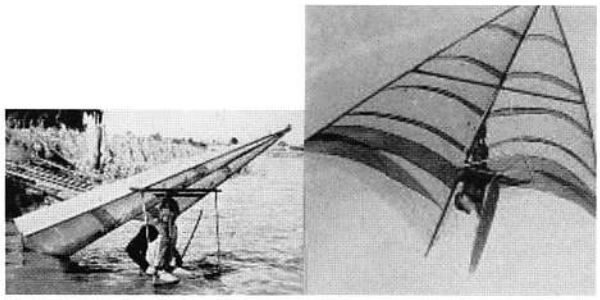

Figure 11 – John Dickenson's Ski Wing of 1963-64

Figure 12 – Bill Bennett's Statue of Liberty flight, 1969

Another significant Rogallo pioneer was Californian Richard Miller, who developed a bamboo Rogallo hang glider with a polyethelene plastic sail in 1969 called the Bamboo Butterfly. This helped generate interest in the sport. On May 23, 1971, a group of hang glider pilots gathered for the first modern day meet near Newport Beach in California to celebrate the 123rd birthday of Otto Lilienthal. This event received widespread media coverage and created further interest in the "new", though actually decades old, sport of hang gliding.

The first substantial soaring flight occurred on September 6, 1971, when Dave Kilbourne soared his Rogallo for 1 hour, 4 minutes at Mission Ridge, California. During 1972-1974, there was an explosion of media coverage with articles in magazines such as Time, Popular Science, Reader's Digest and Sports Illustrated. In 1972, the Southern California Hang Gliding Association formed. There was so much national interest and growth that in December, 1973, the name was changed to the US Hang Gliding association, or USHGA (Reference 21).

It is estimated there were over 40,000 pilots and over 50 makers of Rogallos hang gliders in 1974. Unfortunately, there was also a very high fatal accident rate as there were no government regulation or standards for instruction, pilot skills, or glider certification. Hang gliding's revival followed the same accident trend as the sport of soaring had experienced during the 1920's and 1930's. This was because pilot skills were low, growth was extremely rapid, and glider technology was developing rapidly.

The Standard Rogallo hang gliders could get into a full luffing dive that was unrecoverable at low angles of attack. Several trained engineers were offering kits or plans of more advanced rigid wing gliders with better flying characteristics, though they were more expensive and less convenient to fly.

Safety in the USA improved rapidly as the FAA allowed the USHGA to privately regulate pilot training and the Hang Glider Manufacturer's Association (HGMA) dealt with glider airworthiness. In Europe, the Deutscher Hangegleiter Verband e.v. (DHV) assumed that role. In March, 1975, the USHGA implemented a pilot rating system. In 1978, Bill Bennett started marketing a new innovation: a hand -deployable emergency parachute. The pilot would deploy the parachute and stay attached to the glider in their harness. Ideally the parachute would bring both the pilot and their wing safely to the ground.

Hang glider design technology also evolved rapidly. Rigid battens were added to the sails to define an airfoil shape. Luff-lines and washout tubes were added to retain a nose-up pitching moment at low angles of attack. Pilots flew in the prone rather than the seated position to reduce drag. The cross spar was enclosed within the wing to further reduce drag of the 1980 Ultralight Products Comet. It became the first commercially successful double-surfaced flex-wing glider. (Figure 13).

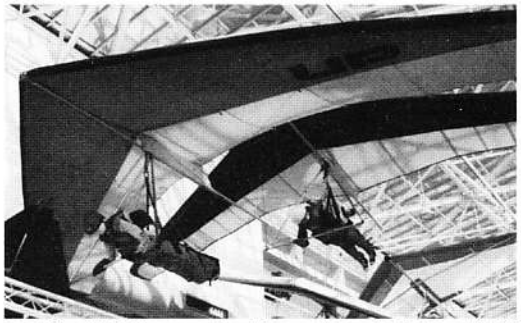

Figure 13 – UP Comet double surfaced glider of 1980

Pilot skills also matured with the first cross-country hang glider flights over 100, 200, 300, and 400 miles in 1977, 1983, 1990, and 2001 respectively. Thankfully, the numbers of fatalities per year dropped from 40 to around 7-10 (Figure 14).

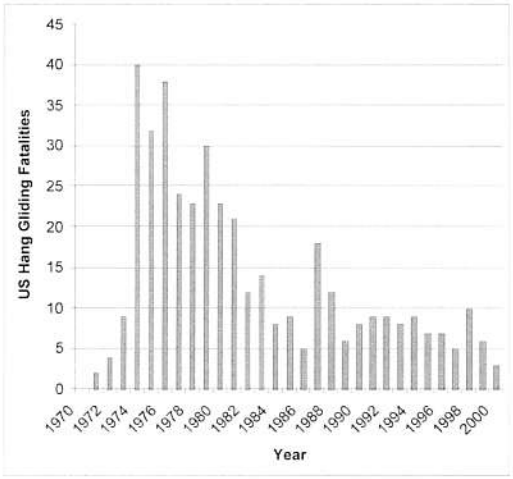

Figure 14 – US Hang Gliding fatalities per year

The numbers of manufacturers also decreased with Wills Wing taking market leadership in the US. Wills Wing began in 1973 by selling Rogallos (Figure 15) and by 2003 has sold over 20,000 hang gliders (Reference 22). Wills Wing currently offers a complete line of training through advanced hang gliders, accessories, and paragliders (Figure 16).

Another class of hang glider developed along with the Rogallo/flex-wing were rigid wing hang gliders. They were available in the 1970's but did not become popular until the Flight Designs Exxtacy was available in 1997 (Figure 17). This glider features a composite D-spar leading edge with integral folding ribs to enhance portability and simple trailing edge flaps. Roll control is enhanced with weight-shift actuated spoilers. It weighs and costs more than a flex-wing hang glider but offers improved performance with good portability (Reference 23).

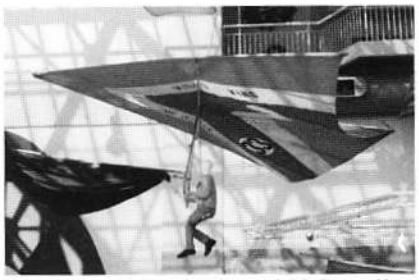

Figure 15 – Bob Wills' winning 1973 Rogallo

Figure 16 – Wills Wing current products

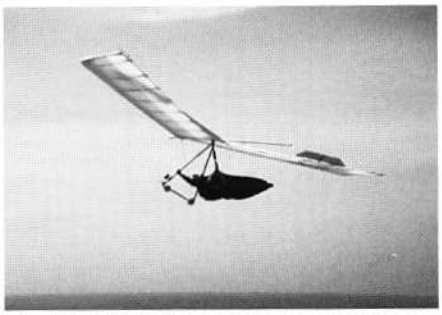

Figure 17 – Flight Design Exxtacy rigid wing

Table 2 shows the maturity of rigid wings. The SWIFT offers the best performance but fulfills only a niche market due to its weight and cost. Note that the Wills Wing Fusion is shown as a flex-wing benchmark.

Year	Glider	L/D	Weight ~lbs.	Cost ~$
1972	Icarus II	7	55	400 kit
1974	Quicksilver	7	56	850
1977	Fledge IIB	9	63	1400
1989	SWIFT	21	115	12500
1997	WW Fusion	12	76	5000
1997	Exxtacy	14	86	8500
1998	Atos	17	74	10000

Table 2 – Rigid wing maturity

A summary of hang glider sink rate performance is shown in Figure 18. Estimates are by the author rather than from the manufacturer.

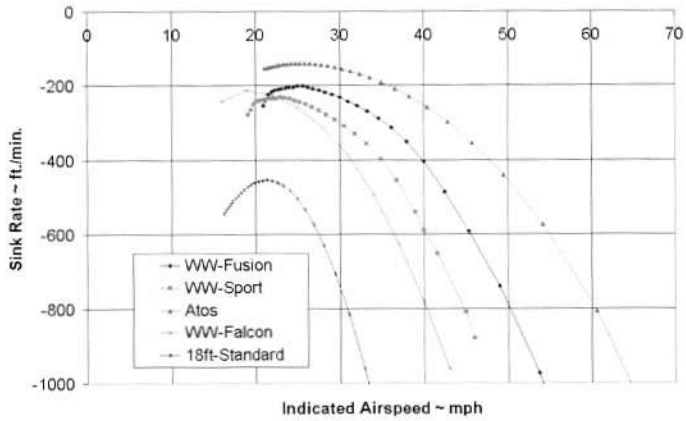

Figure 18 – Hang glider sink rate performance

Recently, hang gliding has benefited greatly from the usage of vehicles and powered ultralights to tow them aloft. The current world distance records set in 2001 of over 400 miles were set by tug-launched flights in Zapata, TX (Reference 24).

POWERED ULTRALIGHT AIRCRAFT

The powered ultralight airplanes of the 1930's faded away as another World War took place. There was a revival in the late 1970's similar to what happened with hang gliding, where it was driven by people with a desire to fly simply with a minimum of training and regulation. In the USA, FAR Part 103 (Reference 1) was implemented in 1982 primarily due to the huge numbers of powered ultralights.

The rebirth of powered ultralights began as hang glider pilots added power to their wings. Barry Palmer foot-launched a powered Rogallo hang glider in 1966 and achieved brief flights skimming along the ground (Figure 19). He also flew a "trike" powered ultralight in 1967 and may have been the first trike pilot (Figure 20).

Figure 19 – Barry Palmer's 1966 powered flight

Figure 20 – Barry Palmer's 1967 trike

Not much happened until Wisconsin resident John Moody added power to his Icarus II hang glider (March 15, 1975) and flew it at the 1976 EAA Oshkosh Airshow (Figure 21 and Reference 25).

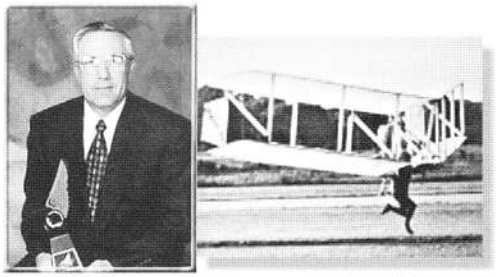
Figure 21 – John Moody and his powered Icarus II

Just like hang gliding, there was a rapid increase in the number of pilots and aircraft and also a high accident rate. Several organizations arose over time to organize ultralight pilots, including the Experimental Aircraft Association (EAA), the United States Ultralight Association (USUA) and Aero Sports Connection (ASC). During the early 1980's there were nearly 100 ultralight manufacturers in the US and just like in hang gliding, their numbers dwindled as the sport matured. They evolved from powered hang gliders to ultralight aircraft to light weight aircraft.

One of the largest US ultralight manufacturers is Quicksilver Aircraft. It began in 1973 as a company called Eipperformance produced a Rogallo hang glider. Eipper also distinguished itself from other brands by offering a rigid wing design called the Quicksilver (Figure 22). As the design evolved, power and landing gear were added and control was still achieved by weight-shift actuated aerodynamic controls (Figure 23).

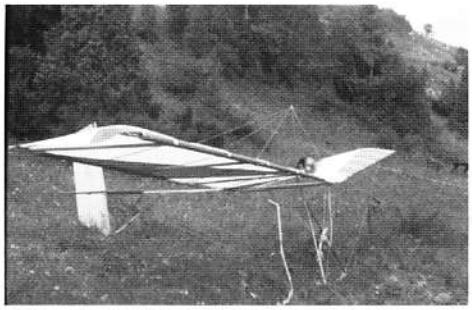
Figure 22 – 1973 Quicksilver hang glider


Figure 23 – 1981 powered Quicksilver MX

The Quicksilver product line continued to evolve and in 1982 they produced 2000 aircraft, more than Cessna, Piper, and Beechcraft combined. In the mid-1980's the GT series was introduced (Figure 24) and to date over 20,000 aircraft have been produced by this company. More information may be found in References 26 and 27.

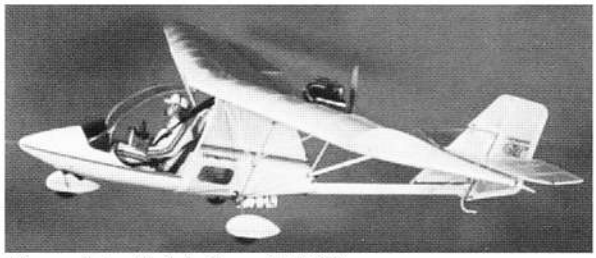
Figure 24 – Quicksilver GT 400

TRIKES AND POWERED PARACHUTES

Other popular types of powered ultralight aircraft include trikes and powered parachutes. Trikes look like hang gliders except the pilot is seated in a tricycle-like structure with landing gear and the engine behind the pilot. As previously mentioned, Barry Palmer flew a trike in 1967. During the 1980's trikes were greatly refined by the Europeans by developing specialized wings rather than merely adding power to hang gliders. Control is solely by weight shift and they were more quickly packed down for transport on a trailer than other ultralights. In the 1990's trikes started finally gaining popularity in the USA (Figure 25).

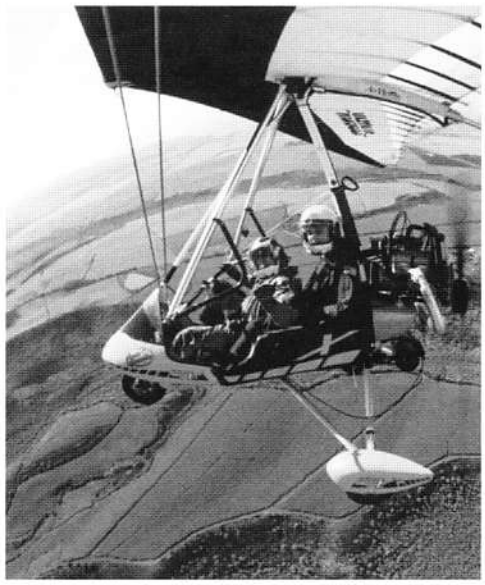
Figure 25 – Two-place trike on a training flight

Powered parachutes became popular in the 1980's and offer simple flight with a very compact aircraft. Powered parachutes are different from powered paragliders by having a triangular structure with landing gear to protect the pilot and house the engine. An example of a powered parachute is shown in Figure 26.

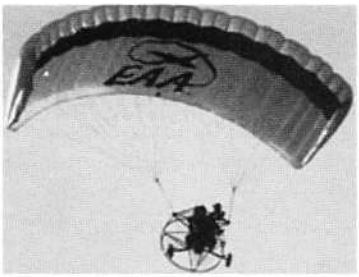

Figure 26 – Powered parachute

PARAGLIDERS – AS SIMPLE AS IT GETS

Francis Rogallo originally called his and Gertrude's invention a "paraglider" and it originally had no fixed structural members. Through the NASA research it evolved to have structure for the leading edges and keel. One individual, David Barish, developed what he called the Sailwing in 1966 (Reference 28). He flew it from ski slopes in Vermont and California, and believed that soaring would be possible under ideal conditions.

In the late 1980's, adventurers developed what became today's paragliders and hiked up European mountains to glide down. Like hang gliding and ultralights, the sport has evolved rapidly and accident rates are coming down. Powered paragliders using small motors attached to the pilot's harness are also available. A paraglider is illustrated in Figure 27.

Figure 27 – Paraglider launch

In the USA, hang gliders and paragliders are organized together within the USHGA and their national publications were combined with the March, 2003 issue. Table 3 highlights some of the principal differences between hang gliders and paragliders.

	Paraglider	Flex-wing hang glider
Rigid structure	No	Yes
Collapses	Yes, rarely	No
Launch ease	No	Yes
Landing ease	Yes	No
Portability	Yes	No
Assembly ease	Yes	No
Sink rate ~ ft/min	< 200	~ 200
Maximum L/D	Lower ~8	Higher ~ 12
Glide speed ~mph	Lower ~20	Higher ~ 28

Table 3 – Paragliders compared with hang gliders

ULTRALIGHT SAILPLANES

There have been lightweight sailplane designs for decades and they typically have been less popular except for training. However, the limiting factor that prevents hang glider pilots from achieving faster cruise speeds and lower drag is the constraint to foot-launch and land their gliders. One technique of achieving greater performance is to evolve into an ultralight sailplane, allowing heavier weight and higher stall speeds. The glider can legally be considered an ultralight if its empty weight is less than 155 pounds. Also, as the hang glider and paraglider pilot population ages it is desirable for many to still fly without having to land on their feet.

In 1974, sailplane home building pioneer Jim Marske developed a flying wing lightweight glider called the Monarch (Figure 28 and Reference 29). In the 1980's, Jim Maupin and Irv Culver developed an ultralight glider called the Carbon Dragon. This glider featured an unprecedented combination of low speed performance and high L/D. The current owner of the prototype Carbon Dragon, Gary Osoba, discovered a new type of soaring known as microlift and has achieved incredible soaring flights in extremely light lift. One example build by Steve Arndt is shown in Figure 29 and Reference 30.

Figure 28 – Marske Monarch

Figure 29 – Steve Arndt's Magic (Carbon) Dragon

A third example of an ultralight glider is the BUG4, or Basic Ultralight Glider, designed and flown by Mike Sandlin. This design philosophy is one of simplicity and ease of construction over high performance (Figure 30 and Reference 31).

Figure 30 – Mike Sandlin's BUG4

A fourth example is a European effort called the Archaeopteryx, which is pursuing an L/D of 28 with a foot-launchable, tail aft configuration (Figure 31 and Reference 32).

Figure 31 - Archaeopteryx

It will be exciting to watch continued development in this niche of ultralight aviation. More information may be found in Reference 33.

SOME FUTURE PREDICTIONS

- Safety will stay at the same level unless technology advances help.
- Technology advances will continue to be privately funded.
- More government regulation is coming soon.
- Convenience will improve more rapidly than performance. This includes: Lighter weight, better handling qualities, improved portability.
- Niche markets for ultra-high performance aircraft will continue to exist.
- Powered ultralights will lose their label and become light airplanes.
- There will be a continued flux of pilots from paragliding to hang gliding to soaring and general aviation.
- An aging pilot population means there will be less participants unless there is increased person-to-person marketing and favorable media exposure.

CONCLUSIONS

1. Ultralight aircraft are here to stay and offer recreational flight to thousands of pilots and jobs for many in a small, viable industry.
2. Hang gliding has undergone 120 years of design development, with concentrated spurts of it in 1891-1909 and 1974-1981.
3. Powered ultralight aircraft began with the Demoiselle and experienced rebirths in the 1920's, 1930's and 1980's.
4. Each form of ultralight aviation experienced its own unnecessary, early high fatality rates, followed by rapid technical development.
5. Accident rates dropped as technology matured and pilot skills grew. The emergency parachute came of age in the 1980's.
6. There are specialized niches for anyone interested in ultralight aviation.

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