Weight-Shift Control Aircraft Flying Handbook

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Preface

The Weight-Shift Control (WSC) Aircraft Flying Handbook introduces the basic pilot knowledge and skills that are essential for piloting WSC aircraft. It introduces pilots to the broad spectrum of knowledge that is needed as they progress in their pilot training. This handbook is for student pilots, as well as those pursuing more advanced pilot certificates.

Student pilots learning to fly WSC aircraft, certificated pilots preparing for additional WSC ratings or who desire to improve their flying proficiency and aeronautical knowledge, and commercial WSC pilots teaching WSC students how to fly should find this handbook helpful. This book introduces the prospective pilot to the realm of WSC flight and provides information and guidance to all WSC pilots in the performance of various maneuvers and procedures.

This handbook conforms to pilot training and certification concepts established by the Federal Aviation Administration (FAA). There are different ways of teaching, as well as performing flight procedures and maneuvers, and many variations in the explanations of aerodynamic theories and principles. This handbook adopts a selective method and concept to flying WSC aircraft. The discussions and explanations reflect the most commonly used practices and principles. Occasionally, the word "must" or similar language is used where the desired action is deemed critical. The use of such language is not intended to add to, interpret, or relieve a duty imposed by Title 14 of the Code of Federal Regulations (14 CFR).

It is essential for persons using this handbook also to become familiar with and apply the pertinent parts of 14 CFR and the Aeronautical Information Manual (AIM). Performance standards for demonstrating competence required for pilot certification are prescribed in the appropriate WSC practical test standard.

This handbook is available for download, in PDF format, from the FAA website, www.faa.gov.

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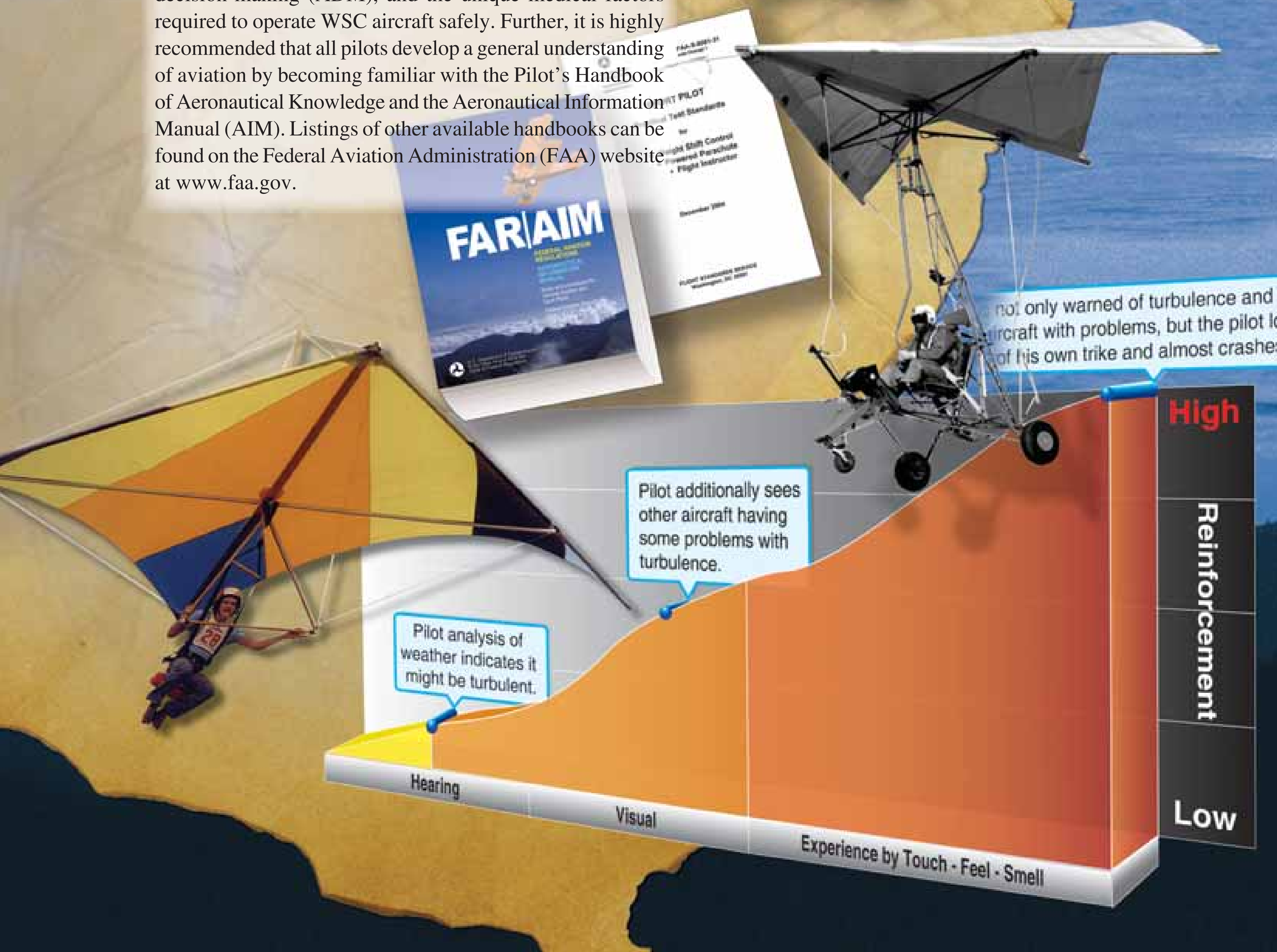
Introduction To Weight-Shift Control

Introduction

Weight-shift control (WSC) aircraft means a powered aircraft with a framed pivoting wing and a fuselage controllable only in pitch and roll by the pilot's ability to change the aircraft's center of gravity (CG) with respect to the wing. Flight control of the aircraft depends on the wing's ability to deform flexibly rather than on the use of control surfaces.

This chapter provides background on the development of the WSC aircraft, its unique characteristics, the requirements for obtaining a WSC license (airman certificate), aeronautical decision-making (ADM), and the unique medical factors required to operate WSC aircraft safely. Further, it is highly recommended that all pilots develop a general understanding of aviation by becoming familiar with the Pilot's Handbook of Aeronautical Knowledge and the Aeronautical Information Manual (AIM). Listings of other available handbooks can be found on the Federal Aviation Administration (FAA) website at www.faa.gov.



History

From the beginning of mankind, we have looked to the skies where legends and myths have entertained and provided us the dream to fly. Through the middle ages, the idea of flight evolved across Europe, with Leonardo Da Vinci well known for designing flying machines to carry humans. In 1874, Otto Lilienthal, a German mechanical engineer, started designing, building, and flying bird-like wings. *[Figure 1-1]* He published his work in 1889, and by 1891 made flights of over 100 feet in distance. Otto was the first successful hang glider pilot to design, build, and fly a number of wing designs. *[Figure 1-2]*

Figure 1-1. *Otto Lilienthal, the German "Glider King."*

In 1903, the Wright brothers' gliders became powered and the airplane was born as the Wright Flyer. In the early 1900s, aircraft configurations evolved as faster speeds and heavier loads were placed on aircraft in flight. As a result of the new demands, the simple flexible wing was no longer sufficient and aircraft designers began to incorporate rigid wings with mechanical aerodynamic controls. These new ideas in wing design eventually resulted in the familiar aileron and rudder configurations found on the modern airplane.

Commercial applications were driving the need for faster and heavier aircraft; however, the dream of achieving manned powered flight in its most bird-like form was evolving along a different path. As rigid wing design enjoyed development for military and commercial applications, the flexible wing concept lay largely dormant for decades. In 1948, a flexible wing design was created by Francis Melvin Rogallo as a flying toy kit for which he obtained a patent in 1951. *[Figure 1-3]*

Rogallo's design concept evolved down two parallel paths in the early 1960s, military and sport flight. The military application was the National Aeronautics and Space Administration (NASA) development of the Rogallo wing into the Paresev (Paraglider Research Vehicle) later renamed the Parawing. That aircraft had rigid leading edges shown in *Figure 1-4*. NASA had the cart attached to the keel hanging below the wing and using weight shift to control the wing in the same fashion as modern WSC aircraft today.

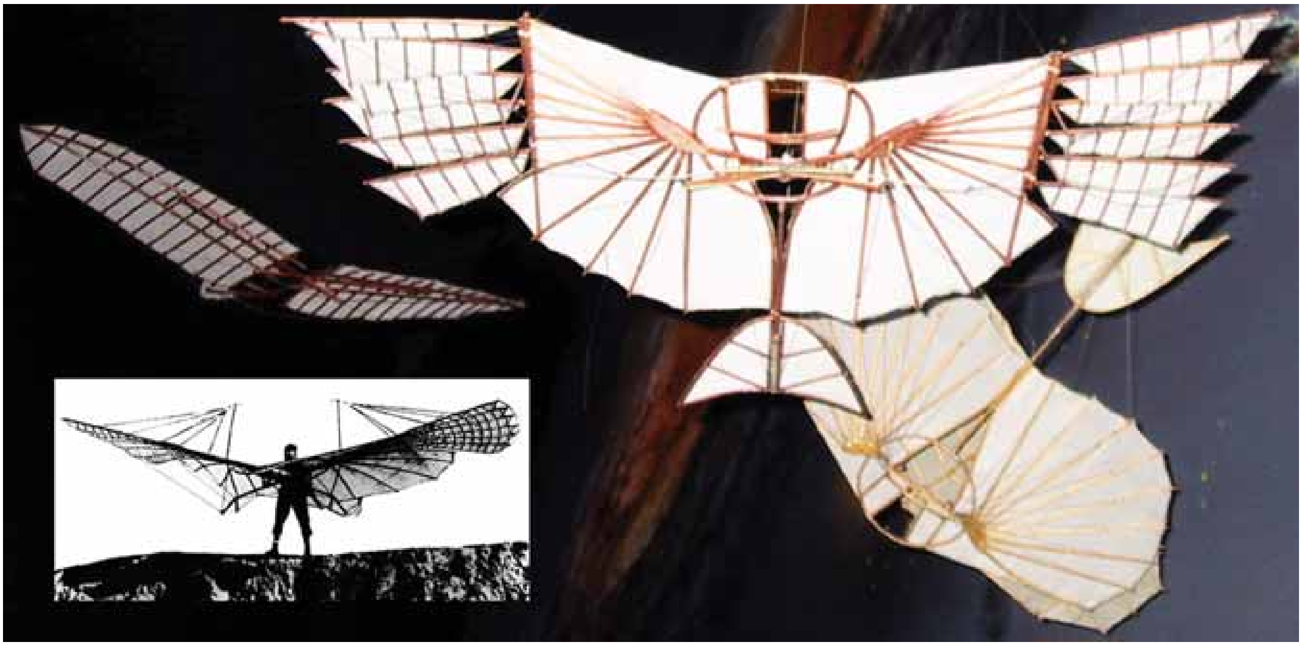


Figure 1-2. *Various models of Otto Lilienthal's glider, the forerunner of weight-shift control aircraft today.*

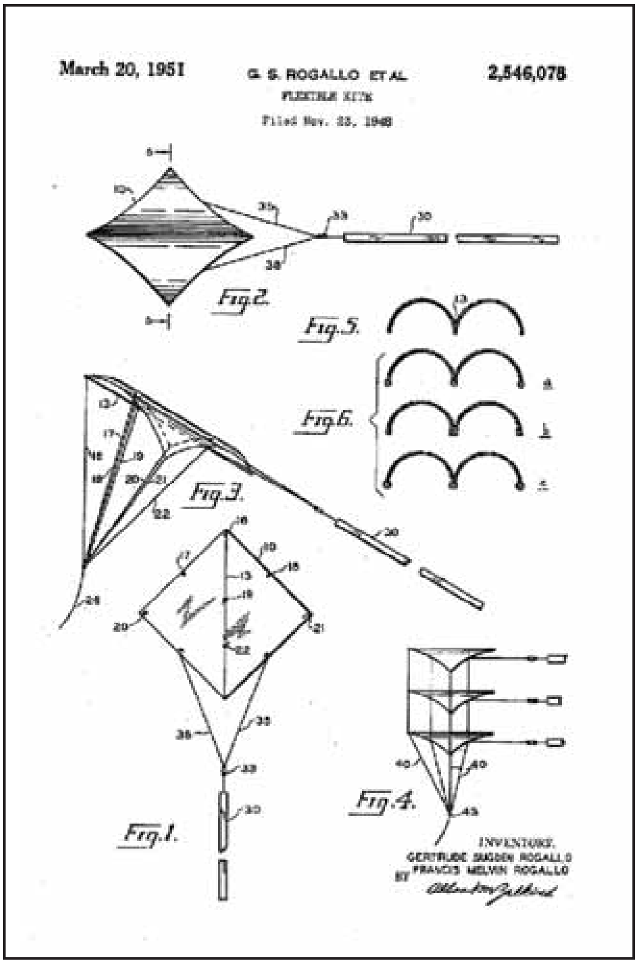


Figure 1-3. *Rogallo's flexible wing for a kite, submitted for patent in 1948.*

Figure 1-4. *NASA testing the Rogallo wing, which led to the modern hang glider and WSC aircraft.*

During this same period, other pioneering engineers and enthusiasts started developing the Rogallo wing for sport. One was aeronautical engineer, Barry Palmer, who saw pictures of the NASA wings and, in 1961, constructed and flew a number of hang gliders based on the Rogallo design. *[Figure 1-5]* His efforts and others evolved to the WSC aircraft in the late 1960s. Another pioneer was John Dickenson of Australia who used the NASA Rogallo wing design but incorporated a triangular control bar that provided structure for the wing during flight with flying wires. *[Figure 1-6]*

Figure 1-5. *Barry Palmer flying a foot-launched hang glider in 1961.*

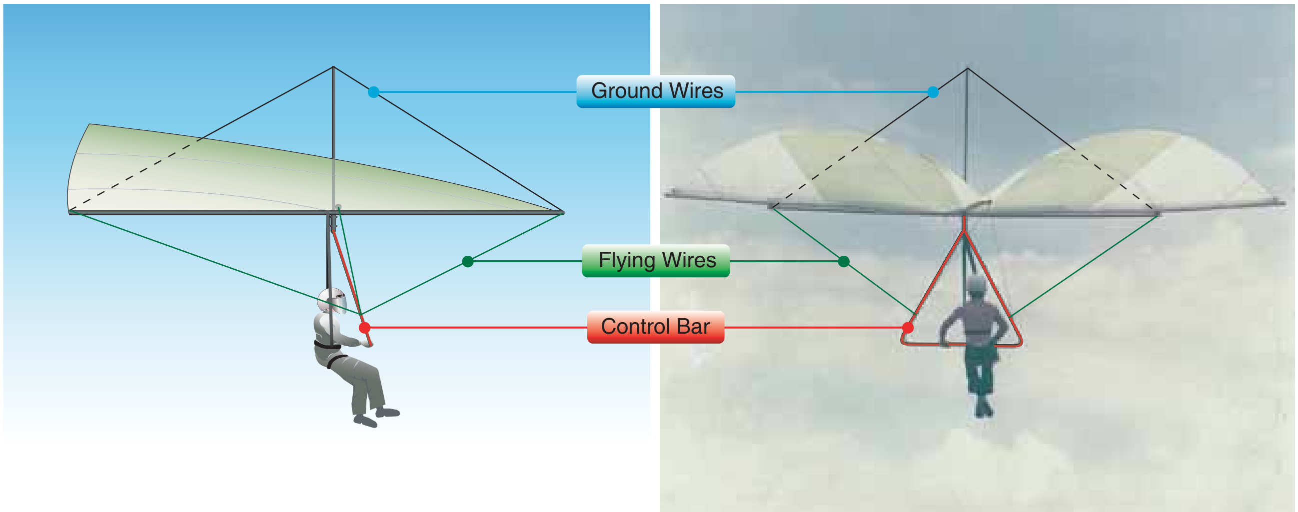


Figure 1-6. *Simple structure added to the Rogallo wing allows wires to hold up the wings on the ground and support the wing in flight.*

Hang Glider

The WSC system and the good flying qualities of the Rogallo wing and Dickenson wing, combined with its easy set-up and portability, started the hang gliding craze in the early 1970s. *[Figure 1-7]* In 1967, the first powered aircraft based on the flexible wing concept of Dr. Rogallo was registered as amateur-built experimental. Flexible wing development continued, and by the early 1970s several adventurous entrepreneurs were manufacturing Rogallo wings for sport use.

Figure 1-7. *An original Rogallo wing, 1975.*

Another significant step in wing design was an airfoil that would change shape for optimum performance at slow and fast speeds. It was the first Rogallo wing with a lower surface that could enclose the structure that holds the wings out. Enclosing this cross bar tube and providing a thicker airfoil similar to the airplane wing provided a jump in high speed performance. This double-surface wing was quickly adopted by manufacturers as the high performance standard and is used on faster WSC aircraft today. *[Figure 1-8]*

Activity in the hang gliding community increased throughout the 1970s, which resulted in the proliferation and development of stable, high-quality modern hang gliders like the one shown in *Figure 1-9*.

Motorized Hang Gliders

In the late 1970s, performance had increased enough to allow motors to be added to hang gliders and flown practically. It was not until the wings had become efficient and the engines and propeller systems evolved that the first commercial motor for a hang glider was introduced in 1977, the Soarmaster. It used a two-stroke engine with a reduction system, clutch, and long drive-shaft that bolted to the wing frame. It had a climb rate as high as 200 feet per minute (fpm) which was acceptable for practical flight. However, during takeoff the wing would overtake the running pilot, and launching was very difficult. Also while flying, if the pilot went weightless or stalled under power, the glider would shoot forward and nose down into a dive. Overall, with the propeller pushing the wing forward during takeoffs and in some situations while flying, this was unsafe for a wide application. *[Figure 1-10]*

A Maturing Industry

Engines and airframe technology had made great advances because the ultralight fixed wing evolution was providing lighter weight, higher power, and more reliable propulsion systems.

The propeller was moved lower for better takeoff and flight characteristics, wheels were added, and the trike was born at the end of the 1970s. A trike describes a Rogallo type wing with a three wheeled carriage underneath (much like a tricycle arrangement with one wheel in front and two in back). Trike is the industry term to describe both ultralight vehicles and

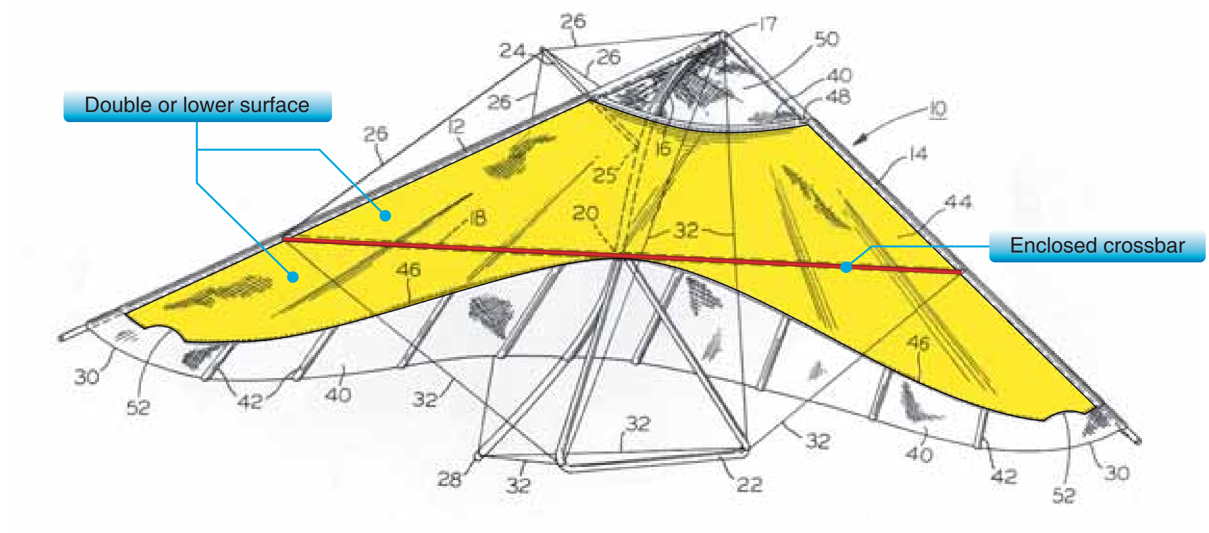


Figure 1-8. *The double-surface patented wing, 1978.*

Figure 1-9. *A modern high-performance hang glider soaring high over the mountains from which it was launched.*

Light-Sport Aircraft (LSA) WSC aircraft. *[Figure 1-11]* The major trike manufacturers were formed in the early 1980s and continue to deliver trikes worldwide today.

New Challenges

By the 1980s, individuals were rapidly developing and operating small powered trikes. This development failed to address the sport nature and unique challenges these new aircraft presented to the aviation community. In an attempt to include these flying machines in its regulatory framework, the FAA issued Title 14 of the Code of Federal Regulations (14 CFR) part 103, Ultralight Vehicles, in 1982. Aircraft falling within the ultralight vehicle specifications are lightweight (less than 254 pounds if powered, or 155 pounds if unpowered), are intended for manned operation

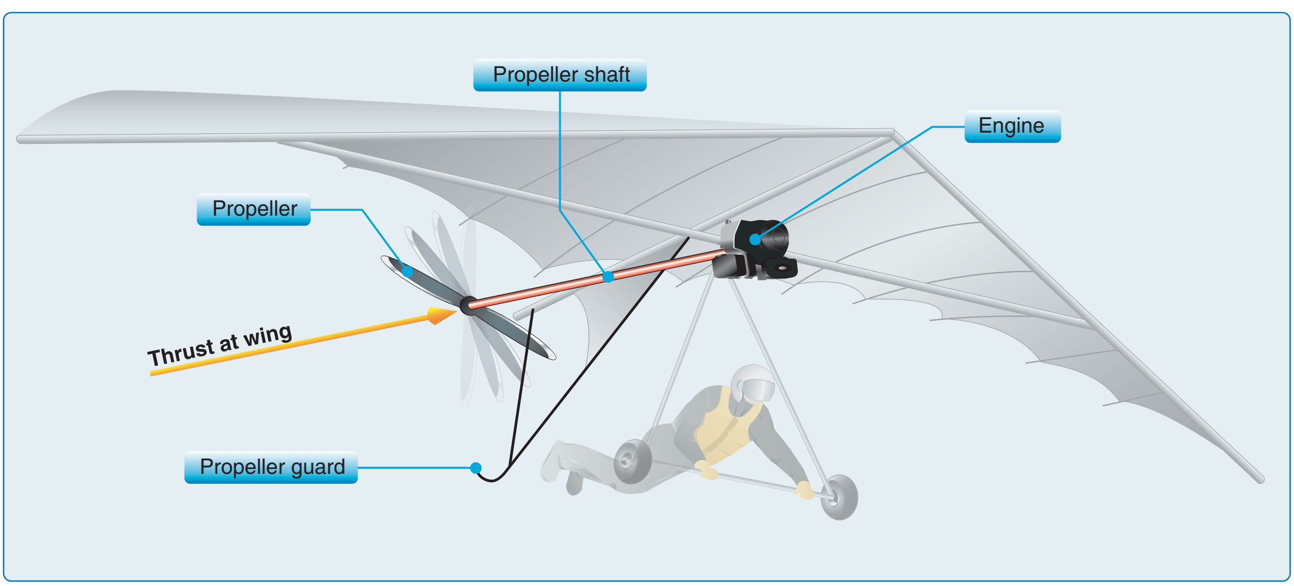


Figure 1-10. *First motorized system design sold as an add-on kit for a hang glider.*

Figure 1-11. *An ultralight vehicle trike: a Rogallo wing on a modified undercarriage.*

by a single occupant, have a fuel capacity of five gallons or less, a maximum calibrated airspeed of not more than 55 knots, and a maximum stall speed of not more than 24 knots. Ultralight vehicles do not require pilot licensing, medical certification, or aircraft registration. Ultralight vehicles are defined in more detail with their operating limitations in 14 CFR part 103.

Because training was so important for the single-place ultralight vehicle pilots, the FAA granted an exemption that allowed the use of two-seat ultralight vehicles for training, and the sport of two-seat ultralight training vehicles grew. Throughout the 1990s, worldwide sales of both single-seat and two-seat ultralight vehicles soared, but it was the proliferation of two-seat trainers that took the industry and the regulators by surprise. Worldwide sales of two-seat ultralight vehicle trainers vastly outnumbered the sales of single-seat ultralight vehicles; and it became clear that the two-seat trainers, which were intended to be operated as trainers only, were being used for sport and recreational purposes. This created a demand for increased comfort and reliability, which resulted in heavier, more sophisticated machines.

Light Sport Aircraft (LSA)

To address the evolution of the ultralight vehicle and its community of sport users, the FAA issued new rules on September 1, 2004. These rules created a new category of LSA and a new classification of FAA pilot certification to fly LSA, called Sport Pilot. Additional guidelines established by the FAA can be found in 14 CFR part 61. *[Figure 1-12]* This handbook focuses on the WSC aircraft.

Aircraft certificated as LSA exceed the limitations defined for ultralight vehicles and require that the pilot possess, at a minimum, a Sport Pilot certificate. The sport pilot rule defines the limitations and privileges for both the sport pilot and the

Figure 1-12. *Examples of LSA, from top to bottom: gyroplane, airplane, powered parachute, and weight-shift control aircraft.*

LSA. In addition, the regulations governing the sport pilot rule define the training requirements of prospective sport pilots and the airworthiness requirements for their machines. For instance, an ultralight vehicle must not exceed 254 pounds or carry more than one person. Aircraft that carry more than one person and weigh over 254 pounds but less than 1,320 pounds may be certified as LSA provided they meet specific certification requirements. Therefore, many WSC ultralight vehicles became LSA (provided they were properly inspected and issued an airworthiness certificate by the FAA).

Weight-Shift Control Aircraft

WSC aircraft are single- and two-place trikes that do not meet the criteria of an ultralight vehicle but do meet the criteria of LSA. The definition for WSC can be found in 14 CFR part 1. Flight control of the aircraft depends on the wing's ability to flexibly deform rather than on the use of control surfaces.

The common acronyms for this LSA are WSC (weight-shift control); WSCL (WSC land), which can be wheels or ski equipped; and WSCS (WSC Sea) for water operations. A LSA WSC used for sport and private pilot flying must be registered with a FAA N-number, have an airworthiness certificate, a pilot's operating handbook (POH), and/or limitations with a weight and loading document aboard. The aircraft must be maintained properly by the aircraft owner or other qualified personnel and have the aircraft logbooks available for inspection. Dual flight controls are required in two-seat aircraft used for training.

The carriage is comprised of the engine and flight deck attached by a structure to wheels, floats, or skis; it may also be referred to as the fuselage. The wing is the sail, structure that supports the sail, battens (ribs) that form the airfoil, and associated hardware. *[Figure 1-13]*

Figure 1-13. *Carriage and wing of a WSC aircraft.*

There are several unique features of the WSC aircraft:

- The wing structure is in the pilot's hands and is used to control the aircraft. There are no mechanical devices between the pilot and the wing. The pilot can directly feel the atmosphere while flying through it because the pilot is holding the wing. This is a direct connection between the wing and the pilot like no other aircraft.
- The pilot can feel the wing as the wingtips or nose moves up and down, but the carriage and passenger are more stable. Turbulence is not felt as much as in a fixed-wing aircraft.
- Different wings can be put on a single carriage. This allows the pilot to have a large wing that can take off in short distances, which would be good for low and slow flying. A large wing with a lightweight carriage can also be used for soaring and is capable of flying at speeds below 30 miles per hour (mph). At the other extreme, a smaller high performance wing can be used for flying long distances at high speeds. With a small wing and a larger motor, WSC aircraft can fly at speeds up to 100 mph.
- The wing can be taken off the carriage and folded up into a tube that can be easily transported and stored. This allows owners to store the WSC aircraft in a trailer or garage, transport the WSC aircraft to a local site, and set it up anywhere. *[Figure 1-14]*

Figure 1-14. *Wing folded and on top of a recreational vehicle with the carriage in a trailer.*

- Since the WSC aircraft is designed without the weight and drag of a tail, the performance is significantly increased. The aircraft can take off and land in short fields, has good climb rates, can handle a large payload, has a good glide ratio, and is fuel efficient. The WSC LSA typically can carry 600 pounds of people, fuel, and baggage.

Besides having large and small wings for different speeds, the WSC aircraft wings can have wires for bracing, struts, or a combination of both. Throughout this handbook, both are used in diagrams and pictures. WSC aircraft are typically on wheels, but there are models that can land and take off on water and snow. *[Figure 1-15]*

Figure 1-15. *WSC aircraft with struts similar to those on an airplane (top) and WSC aircraft operating on water (bottom).*

Weight-Shift Control LSA Requirements

A WSC LSA must meet the following requirements:

1. A maximum takeoff weight of not more than—
    - 1,320 pounds (600 kilograms) for aircraft not intended for operation on water; or
    - 1,430 pounds (650 kilograms) for an aircraft intended for operation on water
2. A maximum airspeed in level flight with maximum continuous power (V_H) of not more than 120 knots calibrated (computed) air speed (CAS) under standard atmospheric conditions at sea level.
3. A maximum stalling speed or minimum steady flight speed without the use of lift-enhancing devices (V_{S1}) of not more than 45 knots CAS at the aircraft's maximum certificated takeoff weight and most critical center of gravity.
4. A maximum seating capacity of no more than two persons, including the pilot.
5. A single reciprocating engine.
6. A fixed or ground-adjustable propeller.
7. Fixed landing gear, except for an aircraft intended for operation on water.
8. Fixed or retractable landing gear, or a hull, for an aircraft intended for operation on water.

Flight Operations and Pilot Certificates

The FAA is empowered by the United States Congress to promote aviation safety by prescribing safety standards for civil aviation programs and pilots. Title 14 of the Code of Federal Regulations (14 CFR), formerly referred to as Federal Aviation Regulations (FAR), is one of the primary means of conveying these safety standards. *[Figure 1-16]* 14 CFR part 61 specifies the requirements to earn a pilot certificate and obtain additional WSC privileges if already a pilot. 14 CFR part 91 is General Operating and Flight Rules for pilots. The Aeronautical Information Manual (AIM) provides basic flight information and operation procedures for pilots to operate in the National Airspace System (NAS).

Figure 1-16. *Federal Aviation Regulations (FAR) and Aeronautical Information Manual (AIM).*