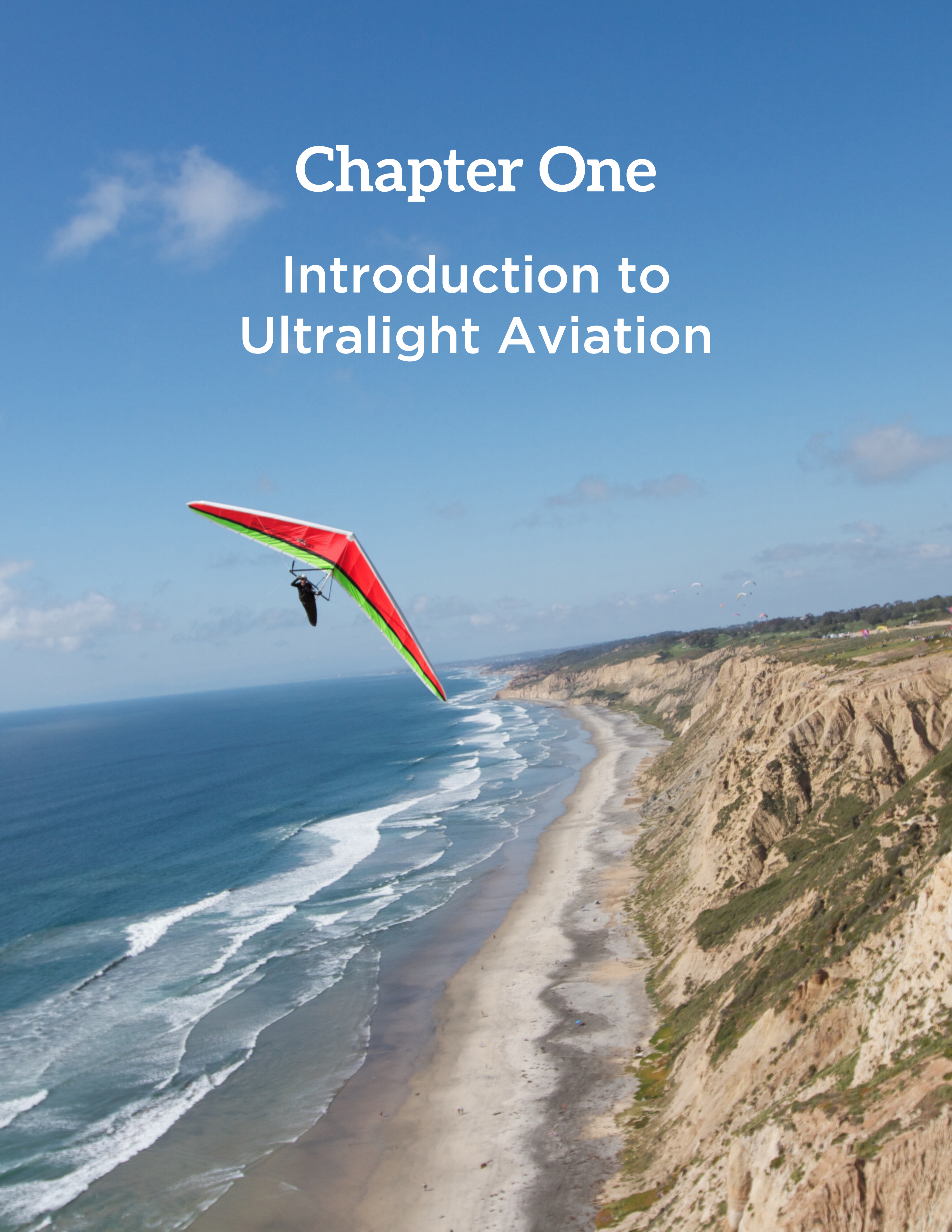
Free Flight Pilot Ground School

Training Manual

Chapter One

Introduction to Ultralight Aviation



This Free Flight Ground School Training Manual is part of the lesson you purchased for hang gliding and paragliding. It is intended as an independent study and please refer to your instructor for further lessons, explanation, and clarification surrounding this material.

Hang Gliding and the Rogallo Wing

In 1853, George Cayley invented a slope-launched, piloted glider. Most early glider designs did not ensure safe flight; the problem was that early flight pioneers did not sufficiently understand the underlying principles that made a bird's wing work. Starting in the 1880s technical and scientific advancements were made that led to the first truly practical gliders, such as those developed in the United States by John Joseph Montgomery. Otto Lilienthal built controllable gliders in the 1890s, with which he could ridge soar. His rigorously documented work influenced later designers, making Lilienthal one of the most influential early aviation pioneers. His aircraft was controlled by weight shift and is similar to a modern hang glider.

Hang gliding saw a stiffened flexible wing hang glider in 1904, when Jan Lavezzari flew a double bateen sail hang glider off Berck Beach, France. In 1910 in Breslau, the triangle control frame with the hang glider pilot hung behind the triangle in a hang glider, was evident in a gliding club's activity. The biplane hang glider was very widely publicized in public magazines with plans for building; such biplane hang gliders were constructed and flown in several nations since Octave Chanute and his tailed biplane hang gliders were demonstrated. In April 1909, a how-to article by Carl S. Bates proved to be a seminal hang glider article that seemingly affected builders even of contemporary times, as several builders would have their first hang glider made by following the plan in his article. Volmer Jensen with a biplane hang glider in 1940 called VJ-11 allowed safe three-axis control of a foot-launched hang glider.

On 23 November 1948, Francis Rogallo and Gertrude Rogallo applied for a kite patent for a fully flexible kited wing with approved claims for its rigid structure and gliding uses; the flexible wing or Rogallo wing, which in 1957 the American space agency NASA began testing in various flexible and semi-rigid configurations in order to use it as a recovery system for the Gemini space capsules. The various stiffening formats and the wing's simplicity of design and ease of construction, along with its capability of slow flight and its gentle landing characteristics, did not go unnoticed by hang glider enthusiasts. In 1960–1962 Barry Hill Palmer adapted the flexible wing concept to make foot-launched hang gliders with four different control arrangements. In 1963 Mike Burns adapted the flexible wing to build a towable kite-hang glider he called Skiplane. In 1963, John W. Dickenson adapted the flexible wing airfoil concept to make another water-ski kite glider; for this, the Fédération Aéronautique Internationale vested Dickenson with the Hang Gliding Diploma (2006) for the invention of the "modern" hang glider. Since then, the Rogallo wing has been the most used airfoil of hang gliders.

Paragliding

In 1966, Canadian Domina Jalbert was granted a patent for a multi-cell wing type aerial device—"a wing having a flexible canopy constituting an upper skin and with a plurality of longitudinally extending ribs forming in effect a wing corresponding to an airplane wing airfoil … More particularly the invention contemplates the provision of a wing of rectangular or other shape having a canopy or top skin and a lower spaced apart bottom skin", a governable gliding parachute with multi-cells and controls for glide.[2]

In 1954, Walter Neumark predicted (in an article in Flight magazine) a time when a glider pilot would be "able to launch himself by running over the edge of a cliff or down a slope … whether on a rock-climbing holiday in Skye or skiing in the Alps."[3]

In 1961, the French engineer Pierre Lemongine produced improved parachute designs that led to the Para-Commander (PC). The Para-Commander had cutouts at the rear and sides that enabled it to be towed into the air and steered, leading to parasailing/parascending.

Domina Jalbert invented the parafoil, which had sectioned cells in an aerofoil shape; an open leading edge and a closed trailing edge, inflated by passage through the air – the ram-air design. He filed US Patent 3131894 on January 10, 1963.[4]

About that time, David Barish was developing the sail wing (single-surface wing) for recovery of NASA space capsules—"slope soaring was a way of testing out ... the Sail Wing."[5] After tests on Hunter Mountain, New York, in September 1965, he went on to promote slope soaring as a summer activity for ski resorts.[6][7]

These developments were combined in June 1978 by three friends, Jean-Claude Bétemps, André Bohn and Gérard Bosson, from Mieussy, Haute-Savoie, France. After inspiration from an article on slope soaring in the Parachute Manual magazine by parachutist and publisher Dan Poynter,[7] they calculated that on a suitable slope, a "square" ram-air parachute could be inflated by running down the slope; Bétemps launched from Pointe du Pertuiset, Mieussy, and flew 100 m. Bohn followed him and glided down to the football pitch in the valley 1000 metres below.[8] Parapente (pente being French for 'slope') was born.

From the 1980s, equipment has continued to improve, and the number of paragliding pilots and established sites has continued to increase. Paragliders and hang gliders have decades of testing, development, and evolution across numerous continents and while all wings are uncertified in the US they are certified to industry standards in Europe.

In the US the United States Hang Gliding and Paragliding Association has worked with the FAA to maintain an exemption that allows paragliders and hang gliders to fly as long as they are within a set and defined standard of operations agreed upon by the FAA. The full Far 103 exemption as it applies to ultralights is listed below. One main restriction of part 103 is that ultralights can only be flown with a single occupant. To allow student pilots to take tandem flights, the USHPA has obtained Exemption 4721 from the FAA for tandem operations. This allows tandem flights for instructional purposes.

PART 103 - ULTRALIGHT VEHICLES

Authority: 49 U.S.C. 106(g), 40103-40104, 40113, 44701.
Source: Docket No. 21631, 47 FR 38776, Sept. 2, 1982, unless otherwise noted.

Subpart A - General

§ 103.1 Applicability.
This part prescribes rules governing the operation of ultralight vehicles in the United States. For the purposes of this part, an ultralight vehicle is a vehicle that:
(a) Is used or intended to be used for manned operation in the air by a single occupant;
(b) Is used or intended to be used for recreation or sport purposes only;
(c) Does not have any U.S. or foreign airworthiness certificate; and
(d) If unpowered, weighs less than 155 pounds; or
(e) If powered:
(1) Weighs less than 254 pounds empty weight, excluding floats and safety devices which are intended for deployment in a potentially catastrophic situation;
(2) Has a fuel capacity not exceeding 5 U.S. gallons;
(3) Is not capable of more than 55 knots calibrated airspeed at full power in level flight; and
(4) Has a power-off stall speed which does not exceed 24 knots calibrated airspeed.

§ 103.3 Inspection requirements.
(a) Any person operating an ultralight vehicle under this part shall, upon request, allow the Administrator, or his designee, to inspect the vehicle to determine the applicability of this part.
(b) The pilot or operator of an ultralight vehicle must, upon request of the Administrator, furnish satisfactory evidence that the vehicle is subject only to the provisions of this part.

§ 103.5 Waivers.
No person may conduct operations that require a deviation from this part except under a written waiver issued by the Administrator.

§ 103.7 Certification and registration.
(a) Notwithstanding any other section pertaining to certification of aircraft or their parts or equipment, ultralight vehicles and their component parts and equipment are not required to meet the airworthiness certification standards specified for aircraft or to have certificates of airworthiness.
(b) Notwithstanding any other section pertaining to airman certification, operators of ultralight vehicles are not required to meet any aeronautical knowledge, age, or experience requirements to operate those vehicles or to have airman or medical certificates.
(c) Notwithstanding any other section pertaining to registration and marking of aircraft, ultralight vehicles are not required to be registered or to bear markings of any type.

Subpart B - Operating Rules

§ 103.9 Hazardous operations.
(a) No person may operate any ultralight vehicle in a manner that creates a hazard to other persons or property.
(b) No person may allow an object to be dropped from an ultralight vehicle if such action creates a hazard to other persons or property.
§ 103.11 Daylight operations.
(a) No person may operate an ultralight vehicle except between the hours of sunrise and sunset.
(b) Notwithstanding paragraph (a) of this section, ultralight vehicles may be operated during the twilight periods 30 minutes before official sunrise and 30 minutes after official sunset or, in Alaska, during the period of civil twilight as defined in the Air Almanac, if:
(1) The vehicle is equipped with an operating anticollision light visible for at least 3 statute miles; and
(2) All operations are conducted in uncontrolled airspace.
§ 103.13 Operation near aircraft; right-of-way rules.
(a) Each person operating an ultralight vehicle shall maintain vigilance so as to see and avoid aircraft and shall yield the right-of-way to all aircraft.
(b) No person may operate an ultralight vehicle in a manner that creates a collision hazard with respect to any aircraft.
(c) Powered ultralights shall yield the right-of-way to unpowered ultralights.
§ 103.15 Operations over congested areas.
No person may operate an ultralight vehicle over any congested area of a city, town, or settlement, or over any open air assembly of persons.
§ 103.17 Operations in certain airspace.
No person may operate an ultralight vehicle within Class A, Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport unless that person has prior authorization from the ATC facility having jurisdiction over that airspace.
[Amdt. 103-17, 56 FR 65662, Dec. 17, 1991]
§ 103.19 Operations in prohibited or restricted areas.
No person may operate an ultralight vehicle in prohibited or restricted areas unless that person has permission from the using or controlling agency, as appropriate.
§ 103.20 Flight restrictions in the proximity of certain areas designated by notice to airmen.
No person may operate an ultralight vehicle in areas designated in a Notice to Airmen under § 91.137, § 91.138, § 91.141, § 91.143 or § 91.145 of this chapter, unless authorized by:
(a) Air Traffic Control (ATC); or
(b) A Flight Standards Certificate of Waiver or Authorization issued for the demonstration or event.
[Doc. No. FAA-2000-8274, 66 FR 47378, Sept. 11, 2001]
§ 103.21 Visual reference with the surface.
No person may operate an ultralight vehicle except by visual reference with the surface.
§ 103.23 Flight visibility and cloud clearance requirements.
No person may operate an ultralight vehicle when the flight visibility or distance from clouds is less than that in the table found below. All operations in Class A, Class B, Class C, and Class D airspace or Class E airspace designated for an airport must receive prior ATC authorization as required in § 103.17 of this part.

Airspace	Flight Visibility	Distance from Clouds
Class A	N/A	N/A
Class B	3 Statute Miles	Clear of clouds 500 feet below
Class C	3 Statute Miles	1,000 ft above 2,000 ft horizontal 500 ft below
Class D	3 Statute Miles	1,000 ft above 2,000 ft horizontal
Class E		
Less than 10,000 ft MSL	3 Statute Miles	500 ft below 1,000 ft above 2,000 ft horizontal
At or above 10,000 ft MSL	5 Statute Miles	1,000 ft above 1 statute mile horizontal
Class G		
1,200ft or less above the surface (regardless of MSL altitude)	1 Statute Mile	Clear of clouds 500 ft below
More than 1,200ft above the surface but less than 10,000ft MSL	1 Statute Mile	1,000 ft above 2,000 ft horizontal 1,000 ft below
More than 1,200ft above the surface and at or above 10,000ft MSL	5 Statute Miles	1,000 ft above 1 statute mile horizontal

Introduction to the Paraglider

The paraglider wing or canopy is usually what is known in engineering as a *ram-air airfoil*. Such wings comprise two layers of fabric that are connected to internal supporting material in such a way as to form a row of cells. By leaving most of the cells open only at the leading edge, incoming air keeps the wing inflated, thus maintaining its shape. When inflated, the wing's cross-section has the typical teardrop aerofoil shape. Modern paraglider wings are made of high-performance non-porous materials such as ripstop polyester[12] or nylon fabric.[note 1]
In some modern paragliders (from the 1990s onwards), especially higher-performance wings, some of the cells of the leading edge are closed to form a cleaner aerodynamic profile. Holes in the internal ribs allow a free flow of air from the open cells to these closed cells to inflate them, and also to the wingtips, which are also closed.[13]

The pilot is supported underneath the wing by a network of suspension lines. These start with two sets of risers made of short (40 cm (16 in)) lengths of strong webbing. Each set is attached to the harness by a carabiner, one on each side of the pilot, and each riser of a set is generally attached to lines from only one row of its side of wing. At the end of each riser of the set, there is a small delta maillon with a number (2–5) of lines attached, forming a fan. These are typically 4–5 m (13–16 ft) long, with the end attached to 2–4 further lines of around 2 m (6.6 ft) m, which are again joined to a group of smaller, thinner lines. In some cases this is repeated for a fourth cascade.

The top of each line is attached to small fabric loops sewn into the structure of the wing, which are generally arranged in rows running span-wise (i.e., side to side). The row of lines nearest the front are known as the A lines, the next row back the B lines, and so on.[14] A typical wing will have A, B, C and D lines, but recently, there has been a tendency to reduce the rows of lines to three, or even two (and experimentally to one), to reduce drag.

Paraglider lines are usually made from UHMW polythene or aramid.[14] Although they look rather slender, these materials are immensely strong. For example, a single 0.66 mm-diameter line (about the thinnest used) can have a breaking strength of 56 kgf (550 N).[15]

Paraglider wings typically have an area of 20–35 square metres (220–380 sq ft) with a span of 8–12 metres (26–39 ft) and weigh 3–7 kilograms (6.6–15.4 lb). Combined weight of wing, harness, reserve, instruments, helmet, etc. is around 12–22 kilograms (26–49 lb).

The glide ratio of paragliders ranges from 8.3 for recreational wings to about 10.3 for modern competition models,[16] reaching in some cases up to 11.[17] For comparison, a typical skydiving parachute will achieve about 3:1 glide. A hang glider ranges from 9.5 for recreational wings to about 16.5 for modern competition models. An idling (gliding) Cessna 152 light aircraft will achieve 9:1. Some sailplanes can achieve a glide ratio of up to 72:1.

The speed range of paragliders is typically 20–75 kilometres per hour (12–47 mph), from stall speed to maximum speed. Beginner wings will be in the lower part of this range, high-performance wings in the upper part of the range.[note 2]

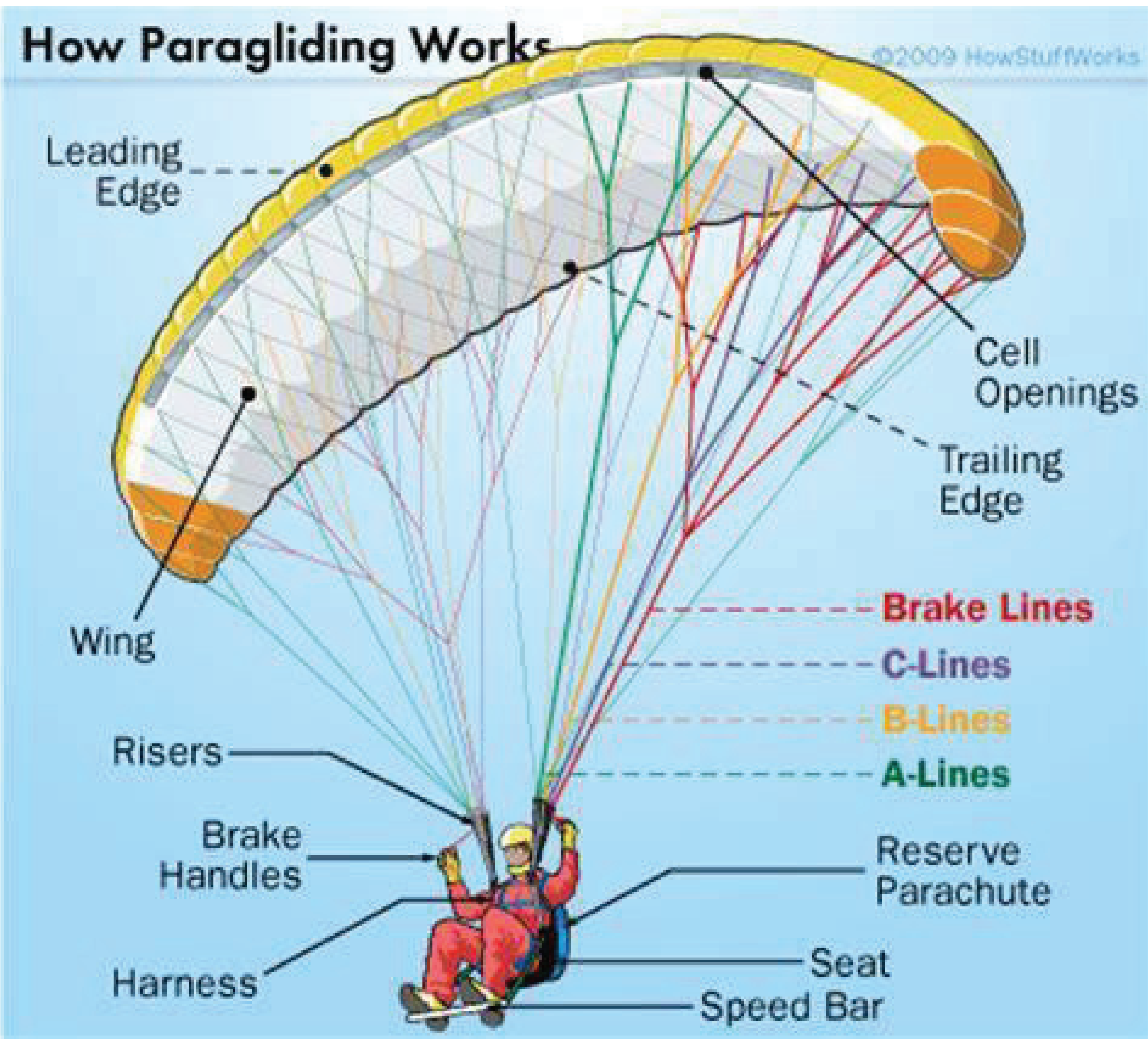
For storage and carrying, the wing is usually folded into a stuffsack (bag), which can then be stowed in a large backpack along with the harness. For pilots who may not want the added weight or fuss of a backpack, some modern harnesses include the ability to turn the harness inside out such that it becomes a backpack.

Harnesses

Modern harnesses are designed to be as comfortable as a lounge chair in the sitting or reclining position. Many harnesses even have an adjustable lumbar support. A reserve parachute is also typically connected to a paragliding harness.

Harnesses also vary according to the need of the pilot, and thereby come in a range of designs, mostly:

- Training harness for beginners
- Pax harness for tandem passengers that often also doubles as a training harness
- XC harness for long-distance cross-country flights
- All-round harness for basic to intermediate pilots
- Pod harness for intermediate to pro pilots that focus on XC
- Acro harnesses, special designs for acrobatic pilots



Other Equipment

Radio - Communicate with instructors and other pilots.
GPS/Variometer- Flight computer that signals rising and sinking air. Glide calculator and maps of terrain.
Garmin In Reach/Spot Locator - GPS trackers that utilize satellites to report last known locations.
Reserve - Every pilot needs to fly with a reserve parachute if they are going to fly over 25 feet AGL. Reserves are deployed by hand and are with circular or square, or steerable delta planforms.

Aeronautical Decision Making (ADM)

A pilot's current attitude or mindset is something the pilot, as PIC, must constantly be alert to in order to maintain your safety and that of the aircraft, a passenger and the general public on the ground. To accomplish sound aeronautical decision making (ADM), the pilot must first be aware of their limitations and well-being (physical and psychological health), even before beginning the first preflight routine. While technology is constantly improving equipment and strengthening materials, safe flight comes down to the decisions made by the human pilot prior to and during flight.

The well-being of the pilot is the starting point for the decision-making processes that will occur while in control of the aircraft. Just as physical fatigue and illness will directly affect your judgment, so too will your attitude management, stress management, risk management, personality tendencies, and situational awareness. Hence, it is the awareness of your human factors and the knowledge of the related corrective action that will not only improve the safety of operating an ultralight but will also enhance the joy of flying. See Chapter 16 of the Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25) to learn the decision-making process, risk management techniques, and hazardous attitude antidotes you should use in all your flight operations.

The phrase "pilot error" points to the human factors which have caused an incident or accident, including the pilot's failure to take appropriate action.

Resource Management

Pilots must make effective use of single-pilot resource management (SRM): human resources (pilot, passenger, maintenance personnel, and the weather briefer, as applicable), hardware (equipment), and information. It is like crew resource management (CRM) procedures that are being emphasized in multi-crew- member operations except only one crewmember (the pilot) is involved. Resource management is one way of optimizing the risk elements (the pilot, the aircraft, the environment, and the type of flight operation). This ability to manage the resources available to you is as critical to the successful outcome of the flight as your skills and procedures as a pilot.

Light-sport aircraft are flown by a single pilot. None-the-less, there are numerous resources available to that pilot. For instance, even though the passenger is not a certified pilot, he or she can be asked to assist with scanning the skies and a possible landing location during an emergency. Your knowledge, skills, and consistent use of a checklist are also valuable resources. External re- sources for the ultralight pilot include those that can assist with Notices to Airmen (NOTAMs) and weather information. These resources can include Automated Weather Observing System (AWOS), Automated Surface Observing System (ASOS), Hazardous Inflight Weather Advisory Service (HIWAS), and Flight Service Stations (FSS) 800-WX-BRIEF.

Use of Checklists

Checklists have been the foundation of pilot standardization and cockpit safety for many years. The check- list is an aid to the fallible human memory and helps to ensure that critical safety items are not overlooked or forgotten. However, checklists are of no value if the pilot is not committed to their use. Without discipline and dedication in using a checklist, the odds favor the possibility of an error.

The importance of consistent use of checklists cannot be overstated in pilot training. A major objective in primary flight training is to establish habitual patterns that will serve the pilot well throughout their entire flying career. The flight instructor must promote a positive attitude toward the use of checklists, and the student pilot must realize its importance.

At a minimum, prepared checklists should be referenced for the following phases of flight:

Preflight Inspection
Before hooking in mental, environmental, and weather check
Hooking into harness, helmet, and reserve check
Clear Runway and Take off corridor
Situational Awareness in flight
Post Flight Visual Inspection of Gear while packing up

Situational Awareness

Situational awareness is the accurate perception and understanding of all the factors that affect the ultralight craft, pilot, passenger, environment, and type of operation comprising a given situation. Maintaining situational awareness requires an understanding of the relative significance of these factors and their future impact on the flight. When situationally aware, the pilot has an overview of the total operation and is not fixated on one perceived significant factor. In addition, an awareness must be maintained of the environmental conditions of the flight, such as spatial orientation of the pilot(s), and its relationship to terrain, traffic, weather, and airspace. To maintain situational awareness, all the skills involved in aeronautical decision making are used. For example, an accurate perception of pilot fitness can be achieved through self-assessment and recognition of hazardous attitudes. Establishing a productive relationship with pattern traffic and traffic control can be accomplished by effective resource use.

Stress Management

Stress is part of the human process. A certain amount of stress can be good as it keeps a person alert and tends to prevent complacency. However, the effects of stress are cumulative. If not coped with adequately, eventually the stress may result in an intolerable burden with negative psychological and perhaps physical consequences. Performance generally increases with the onset of stress, peaks, and then begins to fall off rapidly as stress levels exceed a person's ability to cope. The ability to make effective decisions during flight is likely to be impaired by stress. Hence, the ability to reduce high levels of cockpit stress will have a direct correlation to aircraft safety.

POTENTIAL CAUSES OF ACCIDENTS IN OUTDOOR PURSUITS

A matrix designed by Dan Meyer (1979) and revised by Jed Williamson (1989-2020) ©

Potentially Unsafe Conditions Due To:	Potentially Unsafe Acts Due To:	Potential Errors in Judgment Due To:
• Inadequate Area Security (Physical, Cultural, Political)	• Inadequate Protection	• Desire to Please Others
• Falling Objects (Rocks, etc.)	• Inadequate Instruction	• Trying to Adhere to a Schedule
• Bad Weather	• Inadequate Supervision	• Misperception
• Equipment/Clothing	• Unsafe Speed (Fast/Slow)	• New or Unexpected Situation (Includes Fear and Panic)
• Swift/Cold Water	• Inadequate or Improper Food/Drink / Medications	• Fatigue
• Plants/Animals	• Poor Position	• Distraction
• Physical/Psychological Profile of Participants and/or Staff	• Unauthorized/Improper Procedure (Includes Failing to Follow Directions, Misuse of Technology)	• Miscommunication
		• Disregarding Instincts

Stress management in the aircraft begins by assessing stress in all areas of a pilot's life. There are several techniques to help manage the accumulation of life stresses and prevent stress overload. For example: set realistic goals; manage time more effectively; include relaxation time in a busy schedule; maintain a weekly program of physical fitness; and maintain flight proficiency. If stress does strike in flight, a pilot should try to relax, take a deep breath, and then calmly begin to think rationally through the resolution and decision process.

A wise person once said "there are old pilots, and there are bold pilots, but there are no old bold pilots." Thousands of decisions must be made every single flight. Every single flight will bring different risks. How we assess these risks and manage them before, during, and after our flights will determine our longevity and enjoyment of the sport. In this guide, we will offer you practical ways to remember and recalibrate even in the tumult and euphoria of flight.

As a pilot, it is important to recognize and assess two things before, during and after any flight:

Environmental risk
Self-awareness and personal risk

You will find that these 2 things are closely intertwined in the sport of hang gliding. We will address them in such a way that you can pilot responsibly.

Environmental Risk - Werner Munter's 3x3 tool

Are mountains dangerous? Of course not, mountains and valleys are just there. They only pose a risk to pilots if we choose to fly in too close to the terrain. How high that risk is for you as a hang glider pilot or paraglider pilot depends on your interaction with your environment.

Because there are so many factors around, it is hard to make an objective analysis of the risk without a bit of structure. To help you with this, we will present a simple tool to capture risks and assist you in making good decisions.

Respecting the sky and the power and speed with which it can transform is one of the first steps toward active risk assessment. Greg Heckman, one of the most seasoned pilots in the Southeast, holder of many flying site's distance records, claims we should continue to consider ourselves beginners until we have surpassed over 500 hours of airtime. Respecting the sky or the weather means that you have to learn about the issues and patterns to make intelligent decisions - this takes time, experience, effort, focus and study. According to Michael Robertson, long time instructor, flight school owner and developer of his RCR (Robertson Charts of Reliability) risk management charts... Rule #1 of reliable flying is to know one's limits and stay within them. What's Rule #2? When in doubt, wait it out!

How does a pilot know their limits? We will uncover more on your limits in the next section.

How does one assess and minimize environmental risk? The most important tool is observation. It sounds simple, and it can be. We will help chart out the environmental and personal risks in the 3x3 tool a bit later through the 3 phases of research and observation first at home, then onsite, then in flight.

Personal risk and self-awareness

What are others doing and the power of group think

Listen to the local pilots and observe who is flying when. On rowdy, gusty flying days there will likely be many H4/P4 veterans taking it easy hanging out on launch chatting with their gliders stashed safely away while many eager-beaver H3s/P3s are out white-knuckling it and holding on for dear life while they fly longer than they want for fear of having to land in a potentially unacceptable risk. Just because other pilots are flying, that does not mean a newer pilot should be, or should even want to be flying. There is nothing to prove, make decisions that are best for safety. Every time a pilot hooks in, they are the pilot in command, and they need to ensure flying decisions are being made for them and only them. Leave the ego and peer pressure locked in the backseat, they will not serve you in the sky. This can be a hard thing to do. Many pilots tend to be the types of people who purposefully and enthusiastically seek out new challenges and experiences.

Be aware of the powers of group think, peer pressure and egotism and respect the fact that there can be massive gulfs in experience between pilots with similar flight statistics. Have all fifty of your flights been sunset sledders spread out over the last year and a half? We know, it's tough to find the time to fly when juggling life's demands.

What am I capable of? Where are the limits and do pilots really want to discover their real limit or do they want to sneak up on what is uncomfortable and avoid unacceptable risk?

"There is an adage in the piloting community; do not seek out new, more challenging experiences for they will come to you, whether you like it or not!"

A pilot may have never experienced midday thermal conditions, but that's okay. Keep flying at 10am and sooner or later, a pilot will hit a bubble of lift or sink on final and get introduced to that new variable. Rather than seeking out new, more challenging experiences, what one can do instead is seek out the knowledge and awareness to prepare for these new encounters. A pilot may have dozens of thermalling flights without ever getting thrown "over the falls". Before a H2/P2 jumps into flying in big air, start slowly. Pilots need to gain aerobatic experience to understand how the glider behaves in extreme circumstances. Budget time to build these skills, with ample advice, warnings and supervision from instructors and mentors.

Quick gut-checklist:

What do I want to practice today?
Are these the right conditions for that? (see #1)
If not, what are my options to make the most of today?
If yes, what do I need to make sure of in order to achieve #1...

What are the variables

To practice honing skills, we want to limit exposure to new variables to one new thing at a time. Reinforcing patterns of good decisions will help make flying more natural so that a pilot will be ready to layer in additional variables. Our altitude is the biggest factor in determining our safety margin. The higher a pilot is, the more time and distance we must deal with any unforeseen circumstances and the more opportunity we have to resort to emergency procedures (throwing a reserve) if one needs to.

Here is a list of some common overlooked variables:

New or different harness
New gear
Beginning of the season
Lack of sleep due to travel to site
Emotional challenges
???

"Safety is a book not a word, an attitude more than an action.
It is a practiced pattern not a single step,
Awareness of a broad perspective and attention to fine detail.
Safety is confident and positive yet humble and sensitive.
Safety demands respect and it costs time and money;
It also pays and saves.
Pay now and play longer."
The Art of Sky Sailing: A Risk Management Manual for Hang Gliding and Paragliding
by Michael Robertson

Choosing not to fly can be a tough pill to swallow and may require incredible discipline. Pilots may have travelled hours and/or days to get to a new site, they've dreamed about getting up in the sky for weeks, it's looking like the last good day of the season; the reasons to fly are innumerable. Proudly breaking down on launch while others are flying is a sign of maturity and self-respect. It's a turning point in every pilot's career where they accept that the sky will be there tomorrow and today is just not the day. This is a big leap because it takes accepting our inabilities and/or accepting our unwillingness to test our abilities. It takes more self-awareness and bravery to pack it up than it does to launch into a dangerous and potentially fatal situation. Be proud when you feel that doubt enter your consciousness and allow it to affect your behaviors. Self-preservation is an important value to stay committed to.

Our biggest risks as pilots come from overconfidence and complacency. Both of these elements are wrapped up in the oft-cited Intermediate Syndrome. Intermediate Syndrome can be boiled down to the dynamic of boldness increasing as fear decreases due to a lack of exposure to potential risks. When pilots first start flying, everything seems intimidating. They get a few dozen flights under their belts, get up, soar, experience mechanical and thermal turbulence and suddenly are on top of the world. A pilot suddenly feels like they've got this whole flying thing down! Boy, can they be wrong! Once again, they don't know what they don't know. Just because they have soared in smooth 20 mph winds, that does not mean they are ready to launch on a 15-mph day with a 10-mph gust factor.

Listen to seasoned pilots and learn why one never wants to get stuck behind the ridge, why extra speed on approach never hurts and why low altitude turns are dangerous.

Every time before you launch, ask yourself these questions:

Am I aware of what I am about to get myself into?
Do I have the focus and attention to land safely?
Am I ready for this?
Do I want to do this?

Only fly because you want to fly, because you love it and it brings you an incredible sense of joy and happiness you cannot find anywhere else. If you find yourself launching because "I can do it too," or "I need to prove myself," or "they're expecting me to launch," or "I really need to impress my friends," or "time for a real challenge," you are doing it for the wrong reasons and are setting yourself up for humiliation, injury or worse.

One of the greatest gifts of free flight is that it instantly pushes one to live in the moment. The pilot is there, in that place then, at that specific moment, and that unique combination of space and time is so rare and fleeting or totally unimaginable for most of humanity that one cannot help but bask in its amazingness.

One may not believe it, but it's possible to train to make good decisions. Following and getting used to these new processes will lead to, as we have said, the ability to pilot responsibility.

To recap -

Identify hazards
How to modify in the face of hazards
How to handle the stress of these multi-layers
Willingness to seek out advice and expertise

A big caveat here, is that no matter how much research and study of the sky and flying dynamics, the universe can throw unexpected curve balls a pilot could never expect. That is why complacency is one of the greatest risks in these sports. Accept constructive criticism, stay humble. Decide NOT to fly. Be bold in your dedication to self-preservation. We all love you. We all want to see you fly for years to come. Don't be stupid. Don't go splat. Live to fly another day and help us share the sky with everyone we can. You are in control of your life, act like it.

The 3x3 Tool

Thankfully, models for risk reduction are not new. Skiers and snowboarders use Werner Munter's 3x3 method to assess avalanche danger. With this method, one always makes a choice in a step-by-step plan that leads to a "Go" or "No Go" decision. One big difference with free flight is that pilots do not have an "emergency exit" once in the air. Where a skier can often choose to descend a different slope with a different orientation or less steep terrain, pilots cannot just land on a ridge or tree branch just to calm down and have a look at the risk reduction model map. Yet there are important moments of choice, before and during the flight. So, we rewrote Munter's model for para and hang gliding. When familiar with the system, it will help pilots recognize those moments of choice so you can make a responsible decision.

The model looks at three sets of factors in three different phases.

During the planning and execution of the flight, a distinction is made between the following three phases:

1. At home: Planning at home, with maps, area description, weather forecasts, YouTube and webcams.
2. On site: Observation at the site, such as checking out landing spots and circumstances, reading the site rules.
3. In flight: Decisions during the flight, including the changing (weather) conditions and accessibility of landing sites.

At each of these 3 phases you look at the following 3 factors (3x3):

1. Meteo, including aspects such as wind strength, wind direction etc.
2. Geo, including aspects such as landing field obstructions, downwind terrain etc.
3. Pilot, including aspects such as health, peer pressure, competition pressure etc.

Meteo consists of the expected weather conditions. Meteorological conditions, and their unpredictability, pose a great risk in our sport. Think of an unexpected wind gradient during the landing, or a developing storm cloud on your XC route.

Using the tool:

In phase 1, you get this information from the weather forecast at 'basecamp';
In phase 2, you view the situation from the start and landing spot;
In phase 3, you keep an eye on the weather during the flight.

The factor Geo concerns the condition of the terrain that changes per location and during flight. So, what possibilities does it offer and what dangers lie in wait? Think of a rotor, windy gaps with a lot of sink, or a sloping landing field. Think off them, in all 3 phases.

The factor Pilot refers to yourself, but also to the group you are traveling with, the locals you meet and your equipment. It wouldn't hurt to check each other, both physically and mentally. Again, you should think off them in all 3 phases.

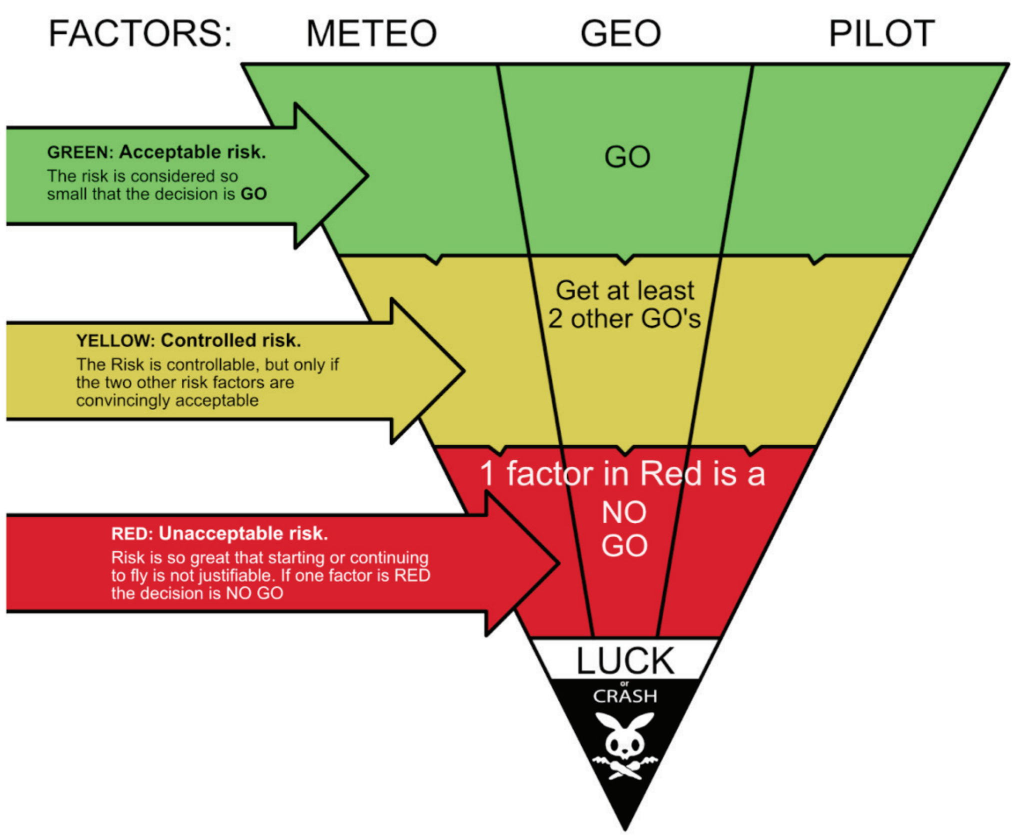
By consciously taking a good decision on these three factors at three different phases (3x3), you can make the risk of an incorrect assessment, and therefore a dangerous situation, very small. Phase 1, the preparation, and creation of a plan can be done in peace at home by immersing yourself in information about the flight area, weather forecasts and webcams to view and make plans with your travel group. Taking the right decisions at the flight site and in the air, you can only learn by practicing a lot (and preferably together) in the real world, going out with schools, or discussing the situation with experienced pilots.

The Fly Filter

With the 3x3 tool the different risks can be analyzed in a simple and organized way. The pilot has to make an assessment whether this analysis leads to a Go or a No Go. The decision process is illustrated in the diagram below, which shows the same three factors of Meteo, Geo and Pilot. For each factor, you can indicate the risk, resulting from the 3x3 tool.

Ideally, all three factors are in the green. If there is one in red, a crash is lurking and luck is still the only safety-net to prevent this. An example: You have bought a new glider, more advanced than you are used to. As a result, the factor of Pilot is burdened with risks with a red edge (new glider and upgraded performance). What can you do to reduce this risk? Consciously choose extra safety in the other factors of meteo and geo. Go to the safest flight spot for that day and do not settle for less than ideal weather conditions.

So, in each of the 3 phases, consider all aspects of the 3 factors in the below diagram.



Fly Fever

The reason that we sometimes, consciously, or unconsciously, take greater risks than is healthy for us is in our human nature. It is not fun to miss a nice flight because the circumstances seem a bit too "sporty", especially when others take off and are high above you. It is also very difficult for us to deviate from an existing plan; this is called ballistic thinking. After an hour-long journey to the starting place, the urge to fly is greater than if you have stepped out of a van or cable car. After all, your effort must be rewarded, right? If you are part of a group, the risk for the group also depends on the behavior and attitude of the group members. Inexperienced pilots often seem to lean on the knowledge, decisions, and actions of the most experienced pilot of the group. So, the experienced pilot, whether they like it or not, sets the example: if they feel pressured to make a socially desirable decision in dubious circumstances, the risk increases for less experienced group members. If you are still on the ground with your flying buddies, you can jointly recite the 3x3 tool and help each other to a democratic "Go" or "No Go". Once you are in the air you must do it yourself.

Risk is Personal

Many pilots faithfully do their checks and have their own method for risk management. Yet quite a lot of accidents happen, among students but also among experienced pilots. That black sucking storm cloud that develops makes no distinction between the seasoned overland pilot that you are (or think you are) and the clumsy pilot who keeps on getting in your way at takeoff. How you take responsibility for your own behavior determines your own safety. Recognizing risk, making decisions, and acting on them is often made difficult due to incorrect observations and / or assessments, stress and peer pressure. It is also possible that you have set the bar too high. In almost all air accidents, the pilot indicates afterwards that the accident could have been prevented if they had done something, not done something, or done something different. Experience, knowledge and expertise, behavior and risk-appetite are decisive factors in this. If you want to fly with managed risk, you will have to learn to recognize and anticipate your personal risks and weaknesses. No method or checklist can ensure that you will fly safe 100%. The 3x3 method presented here is a tool but certainly not a sacred checklist.

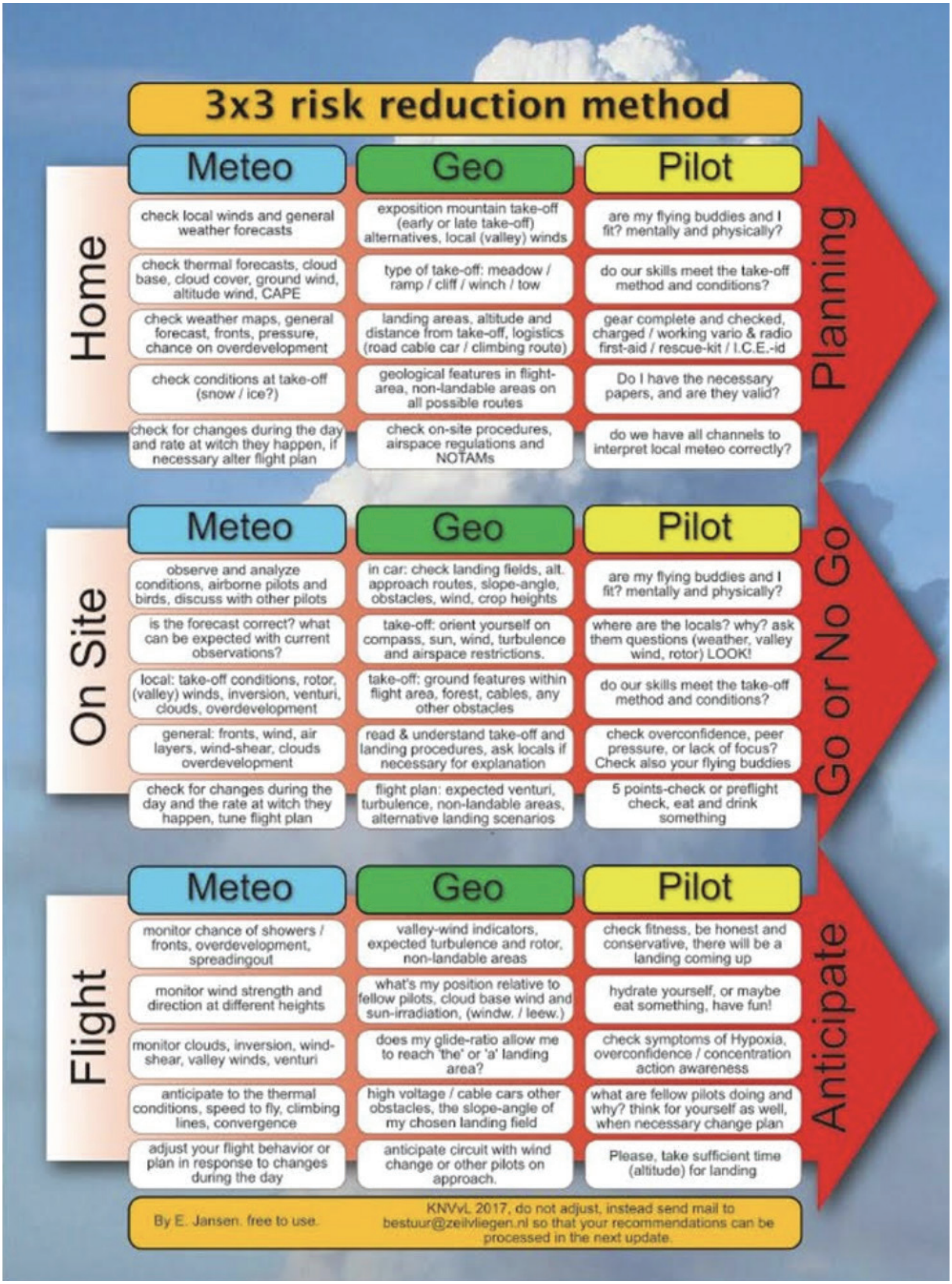
Medical Factors Related to the PPC

Medical factors, regardless of their severity, should never be dismissed without at least a cursory consideration. Even a toothache or the common cold can be detrimental to a safe flight, especially when drugs of any sort, even non-prescription, are taken before the flight. Most medical issues can be easily handled, but a few can have severe influences on the safety of the pilot.

The following medical factors are not listed by importance, but by alphabetical order for easy reference.

Alcohol

Alcohol directly affects the brain and can do so very quickly. Some myths still surround alcohol: drinking coffee can dissipate the effects or taking a cold shower will "sober" you up quickly. The fact is that becoming intoxicated is determined by the amount of alcohol in the bloodstream. Once consumed, alcohol can enter the bloodstream—and therefore the brain— in as quickly as 10 minutes. Once in the brain, motor skills immediately begin to deteriorate. The common aviation saying is "8 hours bottle to throttle." However, depending on the metabolism of the individual, it may be twice as long before some humans can dissipate the negative effects of alcohol. Even in small amounts, alcohol can affect your motor skills, diminish your mental reasoning, decrease your sense of responsibility, and shorten your memory. In addition, the effect of alcohol is greatly multiplied when gaining altitude.


3x3 risk reduction method
Home
Meteo
Geo
Pilot
check local winds and general weather forecasts
exposition mountain take-off (early or late take-off) alternatives, local (valley) winds
are my flying buddies and I fit? mentally and physically?
check thermal forecasts, cloud base, cloud cover, ground wind, altitude wind, CAPE
type of take-off: meadow / ramp / cliff / winch / tow
do our skills meet the take-off method and conditions?
check weather maps, general forecast, fronts, pressure, chance on overdevelopment
landing areas, altitude and distance from take-off, logistics (road cable car / climbing route)
gear complete and checked, charged / working vario & radio first-aid / rescue-kit / I.C.E.-id
check conditions at take-off (snow / ice?)
geological features in flight-area, non-landable areas on all possible routes
Do I have the necessary papers, and are they valid?
check for changes during the day and rate at witch they happen, if necessary alter flight plan
check on-site procedures, airspace regulations and NOTAMs
do we have all channels to interpret local meteo correctly?
Planning
On Site
Meteo
Geo
Pilot
observe and analyze conditions, airborne pilots and birds, discuss with other pilots
in car: check landing fields, alt. approach routes, slope-angle, obstacles, wind, crop heights
are my flying buddies and I fit? mentally and physically?
is the forecast correct? what can be expected with current observations?
take-off: orient yourself on compass, sun, wind, turbulence and airspace restrictions.
where are the locals? why? ask them questions (weather, valley wind, rotor) LOOK!
local: take-off conditions, rotor, (valley) winds, inversion, venturi, clouds, overdevelopment
take-off: ground features within flight area, forest, cables, any other obstacles
do our skills meet the take-off method and conditions?
general: fronts, wind, air layers, wind-shear, clouds overdevelopment
read & understand take-off and landing procedures, ask locals if necessary for explanation
check overconfidence, peer pressure, or lack of focus? Check also your flying buddies
check for changes during the day and the rate at witch they happen, tune flight plan
flight plan: expected venturi, turbulence, non-landable areas, alternative landing scenarios
5 points-check or preflight check, eat and drink something
Go or No Go
Flight
Meteo
Geo
Pilot
monitor chance of showers / fronts, overdevelopment, spreadingout
valley-wind indicators, expected turbulence and rotor, non-landable areas
check fitness, be honest and conservative, there will be a landing coming up
monitor wind strength and direction at different heights
what's my position relative to fellow pilots, cloud base wind and sun-irradiation, (windw. / leew.)
hydrate yourself, or maybe eat something, have fun!
monitor clouds, inversion, wind-shear, valley winds, venturi
does my glide-ratio allow me to reach 'the' or 'a' landing area?
check symptoms of Hypoxia, overconfidence / concentration action awareness
anticipate to the thermal conditions, speed to fly, climbing lines, convergence
high voltage / cable cars other obstacles, the slope-angle of my chosen landing field
what are fellow pilots doing and why? think for yourself as well, when necessary change plan
adjust your flight behavior or plan in response to changes during the day
anticipate circuit with wind change or other pilots on approach.
Please, take sufficient time (altitude) for landing
Anticipate
By E. Jansen. free to use.
KNVvL 2017, do not adjust, instead send mail to bestuur@zeilvliegen.nl so that your recommendations can be processed in the next update.

FAA regulations state that no one may act as a crew- member if they have consumed alcohol within 8 hours of flight, are under the influence of alcohol, are using any drug affecting their faculties contrary to safety, or if they have a blood alcohol level greater than 0.04 percent. Part 61 also states that refusal to take a drug or alcohol test, a conviction for a violation of any Federal or State statute relating to the operation of a motor vehicle (that's right—a car) while under the influence of alcohol or a drug, or failure to provide a written report of each motor vehicle action to the FAA (not later than 60 days after the motor vehicle action) are grounds for:

Denial of an application for any certificate, rating, or authorization for a period of up to 1 year after the date of such refusal; or

Suspension or revocation of any certificate, rating, or authorization.

Anxiety

Anxiety can cause humans to act in unpredictable and negative ways. If a pilot's future is uncertain or an unpredictable event occurs that forces one into an unknown path, anxiety can appear. Self-realization and learned confidence through knowledge and practice are the best ways to prepare for possible anxiety attacks.

Dehydration

Dehydration is the critical loss of water from the body. The first noticeable effect of dehydration is fatigue. A powered parachute pilot is particularly susceptible to dehydration, as they normally fly in an open cart, of- ten exposed for hours to the direct rays of the sun. If dehydration occurs and water is not replaced, fatigue will progress to dizziness, weakness, nausea, tingling of hands and feet, abdominal cramps, and extreme thirst. It is highly recommended for PPC pilots, especially those that fly in desert regions, to carry an ample supply of water and to drink regularly, regardless of whether or not you feel thirsty. When you begin to feel thirsty, the beginning stages of dehydration have already started.

Drugs

One of the biggest misconceptions is the myth that over-the-counter drugs may be taken before a flight. A non-prescription drug does not mean it is free of side effects that may affect your faculties. Consult a physician about mixing flying with any drugs. Many medications such as tranquilizers, sedatives, strong pain relievers, and cough-suppressants have primary effects that may impair judgment, memory, alertness, coordination, vision, and the ability to make calculations. Others, such as antihistamines, blood pressure drugs, muscle relaxants, and agents to control diarrhea and motion sickness, have side effects that may impair the same critical functions.

Pain killers or over-the-counter analgesics, such as Aspirin (acetylsalicylic acid), Tylenol (acetaminophen), and Advil (ibuprofen), have few side effects when taken in the correct dosage. Flying is usually not restricted when taking these drugs. However, flying is almost always precluded while using prescription analgesics such as Darvon, Percodan, Demerol, and codeine, since these drugs may cause side effects such as mental confusion, dizziness, headaches, nausea, and vision problems.

Regulations prohibit pilots from performing duties while using any medication that affects their abilities in any way contrary to safety. The safest rule is not to fly while taking any medication, unless approved to do so by an Aviation Medical Examiner (AME).

Fatigue

Fatigue is frequently associated with pilot error. Many pilots do not want to readily admit that fatigue could be a detrimental factor to their flight skills. Some of the effects of fatigue include degradation of attention, degradation of concentration, impaired coordination, and decreased ability to communicate. These factors can seriously influence a pilot's ability to make effective decisions.

Whether you experience physical fatigue from a lack of sleep or physical work, or mental fatigue from stress, you should consider staying grounded.

Hyperventilation

Hyperventilation occurs when a person is experiencing emotional stress, fright, or pain, and breathing rate and depth increase although the carbon dioxide (CO^2) is already at a reduced level in the blood. The result is an excessive loss of carbon dioxide, which can lead to unconsciousness due to the respiratory system's overriding mechanism to regain breathing control.

The typical symptoms need to be recognized and should not be confused with hypoxia, which shares some indicators. Lightheadedness, feelings of suffocation, and drowsiness can be some of the first signs. Hyperventilation may produce a pale, clammy appearance and muscle spasms compared to the cyanosis and limp muscles associated with hypoxia. As hyperventilation progresses, the pilot may then feel tingling in the extremities, then muscle cramps; cramps that can be become severe and painful. If the pilot doesn't correct breathing, the brain will override consciousness, and cause one to faint while the brain regains control of your breathing.

Hyperventilation can occur when a pilot feels an excessive amount of stress, fear or anxiety. An un- expected or extreme encounter with a thermal or turbulence may unconsciously increase your breathing rate. These situations and the associated feelings tend to increase the rate and size of breath, which then results in clearing too much CO^2 from the body.
The solution is to relax and slow down breathing. This can be accomplished by talking or singing out loud or breathing into a paper bag which keeps fresh oxygenated air from further reducing the CO^2 in your system. Symptoms will rapidly subside after the rate and depth of breathing are brought under control.

Hypoxia

Hypoxia is a lack of oxygen. There are many forms of hypoxia that are beyond the scope and need for discussion in an ultralight manual, but the results from oxygen deficiency are the impairment of the functions of the brain and other organs. Symptoms include headache, drowsiness, dizziness, euphoria, and blue fingernails and lips.

The most likely cause for an ultralight pilot to experience symptoms of hypoxia would be flying too high and being dehydrated. Unless you are a private pilot with a powered parachute rating you need to stay below 10,000 feet without supplemental oxygen where you will have less chance of experiencing hypoxia. However, if you are acclimated to sea level conditions and climb above 8,000 feet, you may feel the effects of hypoxia. The longer you stay at altitude, the greater the effects of hypoxia will be. In addition, recent consumption of alcohol, smoking, and some medications will render a pilot more susceptible to disorientation and hypoxia. If you question your condition and consider hypoxia to be a potential problem, you should fly at lower altitudes and/or use supplemental oxygen.

Motion Sickness

Motion sickness, or airsickness, is caused by the brain sending conflicting messages about the orientation of the body. The inner ear—specifically the vestibular system—is reporting one spatial orientation, and the eyes are communicating a different scenario. This not only causes confusion in your thinking, but it may also possibly create vertigo or spatial disorientation. It often causes vomiting and a debilitating feeling. Vomiting is due to a nerve that is connected from the brain to the stomach. When confusion or disagreement occurs be- tween the eyes and the orientating vestibular system, vomiting may erupt.

When symptoms of motion sickness begin, get back on the ground. In the meantime, avoid unnecessary head movements and keep your eyes on the horizon.

As the pilot, you should note if the passenger, who had been talking throughout the flight, gets quiet. You should ask "how are you doing" because getting quiet is sometimes a precursor to feelings of nausea. Inform passengers while still on the ground to let you know if their stomach begins to feel "uneasy."

Motion sickness can be the result of continued flight stimulation, such as rapid or unexpected turns and swinging through the pendulum. As the pilot, you will find a reduced rate of upset stomachs if you let the passenger know, ahead of time, the flight maneuver you are about to make and avoid abrupt maneuvers.

For new students, anxiety and stress may greatly con- tribute to motion sickness. However, after a few lessons and sometime in the air from the front seat, these feelings/symptoms will usually dissipate.

Medication like Dramamine can be used to prevent motion sickness/nausea in passengers, but since it can cause drowsiness, it is not recommended for the pilot.

Scuba Diving

Taking a flight, especially a high flight, after a deep scuba dive can have some devastating results. This is because the increased pressure of the water during a dive causes nitrogen to be absorbed into the body tissues and bloodstream. Then, when flying at altitudes of reduced atmospheric pressure, the nitrogen will move out of the bloodstream and tissues at a rapid rate. This rapid outgassing of nitrogen is called the bends (as it is felt in the joints—the bending joints of the limbs) and is painful and incapacitating.

A pilot or passenger who intends to fly after scuba diving should allow the body sufficient time to rid it- self of excess nitrogen that was absorbed during the dive. If the appropriate amount of time is not allowed, decompression sickness due to gases released in the blood can result in a serious in-flight emergency.

As an absolute standard safety measure, any pilot fly ing near a large body of water should ask the passen ger during the preflight if he or she has recently been scuba diving.

The following waiting times are recommended:

	Dives Not Req. Controlled Ascent	Dives Req. Controlled Ascent
Flights up to 8,000 feet MSL	A minimum of 12 hrs.	A minimum of 24 hrs.
Flights above 8,000 feet MSL	A minimum of 24 hrs.	A minimum of 24 hrs.

Spatial Disorientation

Spatial disorientation is not normally associated with slow and low (non-aerobatic) flights. However, it is important to know that spatial disorientation is a condition of the body's confusion relative to the spatial position. This commonly results from the eyes disagreeing with the sense of balance (the vestibular system of the inner ear) which may be disagreeing with the postural nerve impulses from the pressure areas in the skin and muscles. Hence, the brain gets conflicting spatial information. This condition is sometimes called vertigo.

The recommended procedure to deal with spatial disorientation is to maintain constant, straight and level flight via the throttle and remove all control input to the steering controls.

Stress

Stress is a strong factor in pilot error. Stressful situations are very disruptive conditions. There are three categories of stress: environment (physical, such as loud noises), psychological (the loss of a loved one) and physiological (fatigue). Any of these factors can be influential on your mental capacities, and hence should be given consideration when beginning your medical self-evaluation prior to preflight inspection. Any pilot experiencing a high level of stress is not safe and should not fly as PIC.

Stroke and Heart Attack

In the event you feel light-headed or dizzy, you should remove your feet from an input position on the steering controls. When you feel light-headed or dizzy, there is a possibility this could be a prelude to a heart attack or stroke. If you are about to experience a medical problem of this magnitude, then you could have a seizure or leg spasms (due to the pain from the heart attack) and therefore, uncontrollably and with- out intention, spiral yourself into the ground if the leg spasm induces severe steering input.

If you don't feel "right"— pull your feet away from those steering controls, at least until you begin to feel better, and then get yourself safely on the ground as soon as possible.

Medical Summary— "The Bottom Line"

Before even approaching a paraglider, hang glider, or powered paraglider, you must take a moment to reflect upon your current medical, physical, and psychological condition. It is in this reflective moment that you should begin to evaluate your ability to safely conduct the flight.

Once satisfied with your self-evaluation, the preflight inspection can then con- tinue. Using the "I'M SAFE" checklist is a smart way to start your preflight before getting to the powered parachute. Prior to flight, assess your fitness as well as the aircraft's airworthiness. *[Figure 1-5]*

Figure 1-5. Prior to flight you should assess your fitness, just as you evaluate the aircraft's airworthiness.

Your preflight preparations should include evaluating the airworthiness of the:

Pilot: experience, sleep, food and water, drugs/medications, stress, illness
Aircraft: fuel, weight (does not exceed maximum), density altitude, takeoff and landing requirements, equipment
EnVironment: weather conditions and forecast for departure and destination airfields and route of flight, runway lengths
External pressures: schedules, available alternatives, purpose of flight

Often remembered as PAVE, it is important for you to consider each of these factors and establish your own personal minimums for flying.

- Accept no unnecessary risk. Flying is not possible without risk, but unnecessary risk comes without a corresponding return. If you are flying a new airplane for the first time, you might determine that the risk of making that flight in low visibility conditions is unnecessary.

- Make risk decisions at the appropriate level. Risk decisions should be made by the person who can develop and implement risk controls. Remember that you are pilot-in-command, so never let anyone else—not ATC and not your passengers—make risk decisions for you.

- Accept risk when benefits outweigh dangers (costs). In any flying activity, it is necessary to accept some degree of risk. A day with good weather, for example, is a much better time to fly an unfamiliar airplane for the first time than a day with low IFR conditions.

- Integrate risk management into planning at all levels. Because risk is an unavoidable part of every flight, safety requires the use of appropriate and effective risk management not just in the preflight planning stage, but in all stages of the flight.

Hazardous Attitudes and Antidotes

Being fit to fly depends on more than just a pilot's physical condition and recent experience. For example, attitude affects the quality of decisions. Attitude is a motivational predisposition to respond to people, situations, or events in a given manner. Studies have identified five hazardous attitudes that can interfere with the ability to make sound decisions and exercise authority properly: anti-authority, impulsivity, invulnerability, macho, and resignation. *[Figure 1-6]*

Hazardous attitudes contribute to poor pilot judgment but can be effectively counteracted by redirecting the hazardous attitude so that correct action can be taken. Recognition of hazardous thoughts is the first step toward neutralizing them. After recognizing a thought as hazardous, the pilot should label it as hazardous, then state the corresponding antidote. Antidotes should be memorized for each of the hazardous attitudes so they automatically come to mind when needed.

Likelihood of an Event

Likelihood is nothing more than taking a situation and determining the probability of its occurrence. It is rated as probable, occasional, remote, or improbable. For example, a pilot is flying from point A to point B (50 miles) in marginal visual flight rules (MVFR) conditions. The likelihood of encountering potential instrument meteorological conditions (IMC) is the first question the pilot needs to answer. The experiences of other pilots, coupled with the forecast, might cause the pilot to assign "occasional" to determine the probability of encountering IMC.

The following are guidelines for making assignments:

Probable—an event will occur several time
Occasional—an event will probably occur sometime
Remote—an event is unlikely to occur, but is possible
Improbable—an event is highly unlikely to occur

The Five Hazardous Attitudes	Antidote
Anti-authority: "Don't tell me." This attitude is found in people who do not like anyone telling them what to do. In a sense, they are saying, "No one can tell me what to do." They may be resentful of having someone tell them what to do or may regard rules, regulations, and procedures as silly or unnecessary. However, it is always your prerogative to question authority if you feel it is in error.	**Follow the rules. They are usually right.**
Impulsivity: "Do it quickly." This is the attitude of people who frequently feel the need to do something, anything, immediately. They do not stop to think about what they are about to do, they do not select the best alternative, and they do the first thing that comes to mind	**Not so fast. Think first.**
Invulnerability: "It won't happen to me." Many people falsely believe that accidents happen to others, but never to them. They know accidents can happen, and they know that anyone can be affected. However, they never really feel or believe that they will be personally involved. Pilots who think this way are more likely to take chances and increase risk	**It could happen to me.**
Macho: "I can do it." Pilots who are always trying to prove that they are better than anyone else think, "I can do it—I'll show them." Pilots with this type of attitude will try to prove themselves by taking risks in order to impress others. While this pattern is thought to be a male characteristic, women are equally susceptible	**Taking chances is foolish.**
Resignation: "What's the use?" Pilots who think, "What's the use?" do not see themselves as being able to make a great deal of difference in what happens to them. When things go well, the pilot is apt to think that it is good luck. When things go badly, the pilot may feel that someone is out to get them or attribute it to bad luck. The pilot will leave the action to others, for better or worse. Sometimes, such pilots will even go along with unreasonable requests just to be a "nice guy."	**I'm not helpless. I can make a difference.**

Figure 1-6. The five hazardous attitudes identified through past and contemporary study.

Risk Assessment Matrix

Likelihood	Severity			
	Catastrophic	Critical	Marginal	Negligible
Probable	High	High	Serious	
Occasional	High	Serious		
Remote	Serious	Medium		Low
Improbable				

Figure 1-7. This risk matrix can be used for almost any operation by assigning likelihood and consequence. In the case presented, the pilot assigned a likelihood of occasional and the severity as catastrophic. As one can see, this falls in the high risk area.

Severity of an Event

The next element is the severity or consequence of a pilot's action(s). It can relate to injury and/or damage. If the individual in the example above is not an instrument rated pilot, what are the consequences of him or her encountering inadvertent IMC conditions? In this case, because the pilot is not IFR rated, the consequences are catastrophic.

The following are guidelines for this assignment:

Catastrophic—results in fatalities, total loss
Critical—severe injury, major damage
Marginal—minor injury, minor damage
Negligible—less than minor injury, less than minor system damage

Simply connecting the two factors as shown in Figure 1-7 indicates the risk is high and the pilot must either not fly or fly only after finding ways to mitigate, eliminate, or control the risk.

In any incident there is a series of mental decisions that are made in very rapid succession. Your ability to perform them well could be the difference between an incident and an accident.

Detect (the Problem)

Problem detection is the first step in the decision-making process. It begins with recognizing a change occurred or an expected change did not occur. A problem is perceived first by the senses and then it is distinguished through insight and experience. These same abilities, as well as an objective analysis of all available information, are used to determine the nature and severity of the problem. One critical error made during the decision-making process is incorrectly detecting the problem. .

Estimate (the Need To React)

Determine a set of choices that narrow down the response matrix to a manageable grid that address the specific problem in question. The problem has not changed, but the perception of risk a pilot assigns it changes because of the multitude of ongoing tasks and the environment. Experience, discipline, awareness, and knowledge influences how a pilot ranks a problem. Determine severity of problem and need for response.

Choose (a Course of Action)

After the problem has been identified and its impact estimated, the pilot must determine the desirable outcome and choose a course of action.

Identify (Solutions)

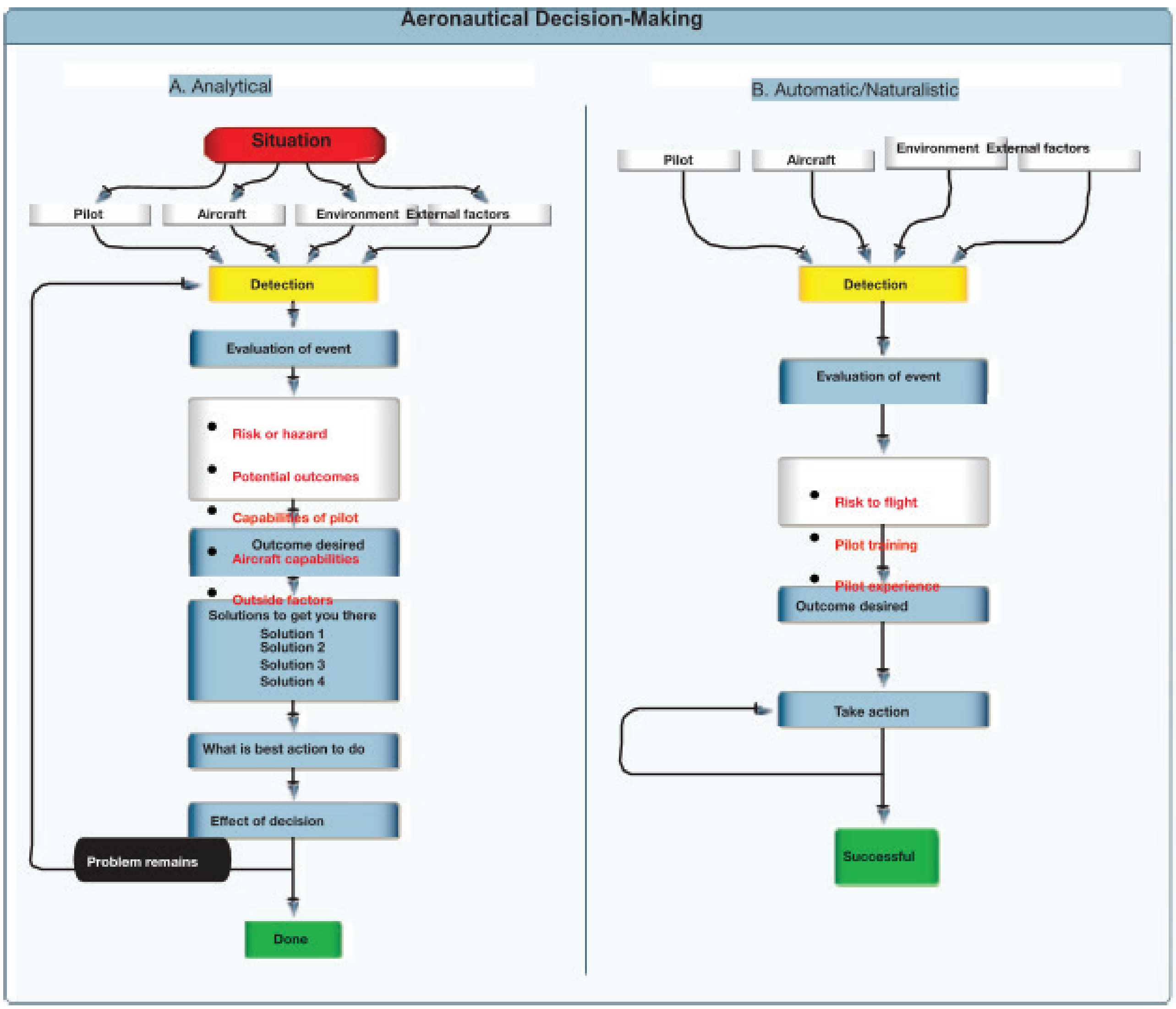
The pilot formulates a plan that will take him or her to the objective. Sometimes, there may be only one course of action available. It is important for the pilot not to become fixated on the process to the exclusion of making a decision.

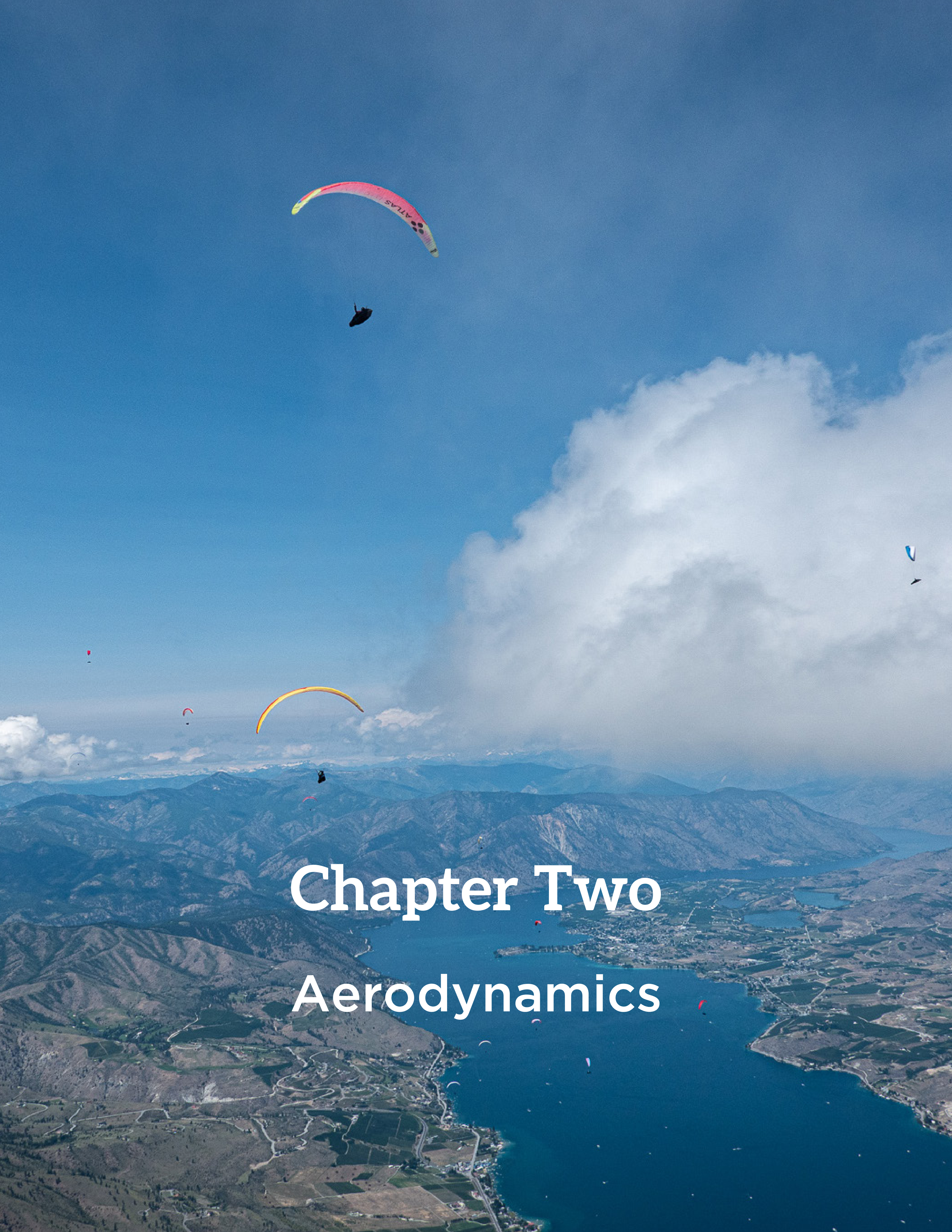
Do (the Necessary Actions)

Once pathways to resolution are identified, the pilot selects the most suitable one for the situation.

Evaluate (the Effect of the Action)

Finally, after implementing a solution, evaluate the decision to see if it was correct. If the action taken does not provide the desired results, the process may have to be repeated.





Chapter Two

Aerodynamics

Aerodynamic Terms

Airfoil is the term used for surfaces on a wing that produce lift, typically the wing itself. Although many different airfoil designs exist, all air- foils produce lift in a similar manner.

Camber refers to the curvature of a wing when look ing at a cross section. A wing possesses upper cam- ber on its top surface and lower camber on its bottom surface. Leading edge describes the forward edge of the airfoil. The rear edge of the airfoil is called the trailing edge. The chord line is an imaginary straight line drawn from the leading edge to the trailing edge. *[Figure 2-1]*

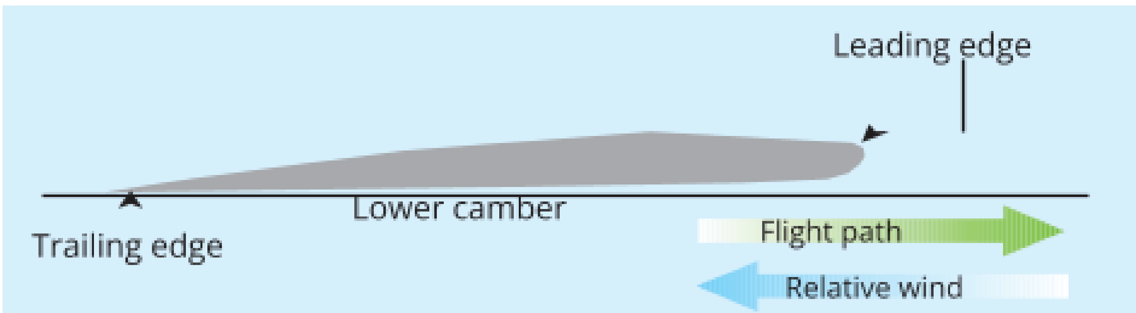


Figure 2-1. Aerodynamic terms of an airfoil.

Relative wind is the direction of the airflow with respect to the wing; it is usually parallel to and opposite   the flight path. Relative wind may be affected by movement of the PPC through the air, as well as by all forms of unstable, disturbed air such as wind shear, thermals, turbulence, and mountain rotors. When a PPC is flying through undisturbed air, the relative wind is parallel to and opposite the flight path.

Angle of incidence is the angle formed by the chord line of the wing and the longitudinal axis of the pilots.] Unlike an airplane, the angle of incidence can change in flight because of the flex- ible line attachment between the wing and the pilot.

Trim angle is the angle between the chord line of the wing and the horizontal plane when the ultralight is in non- powered gliding flight. This "trim angle" is built into the wing by the manufacturer and cannot be adjusted by the pilot moving the controls.

Pitch angle is the angle the wing chord makes with the horizontal plane. Pitch angle is what you can see. Many pilots confuse the pitch angle, which you can easily see and feel, with the angle of attack which may not be as perceptible.

Angle of attack is the angle between the relative wind and the wing chord line. *[Figure 2-2]*

The angle of attack is the angle at which the relative wind meets the wing profile. In normal flight the paraglider remains at a constant angle of attack and at a constant airspeed. The pilot can influence the angle of attack and thus the speed by using the brakes or speed system or trimmer system on a tandem paraglider or my pulling in or pushing out on the control bar in a hang glider. The angle of attack and airspeed are very much related: if you change the angle of

attack the airspeed too will change until a new equilibrium is achieved. The angle of attack can be increased by applying the brakes, evenly this causes a corresponding decrease in airspeed. The greater the angle of attack, the more lift is produced, however, more drag is also produced. If too much brake is applied, or if a hang glider pushes out too much, then the smooth airflow over the profile cannot be maintained and the airflow breaks away from the top surface:
This is known as a stall. Being aware of the stall is very important when learning to fly since inadvertent stalls are very dangerous and should be avoided, always keep your hands high and make sure you feel good airspeed on your face whilst trying to avoid the stall. Only when making the landing flare should the pilot use deep and heavy brake inputs. The angle of attack can be decreased using the accelerator system, as the angle decreases drag is reduced and the speed increases. At low angles of attack, paragliders and hang gliders are more prone to collapse. This is why you should not use the speed system when close to the ground or flying in turbulent air.

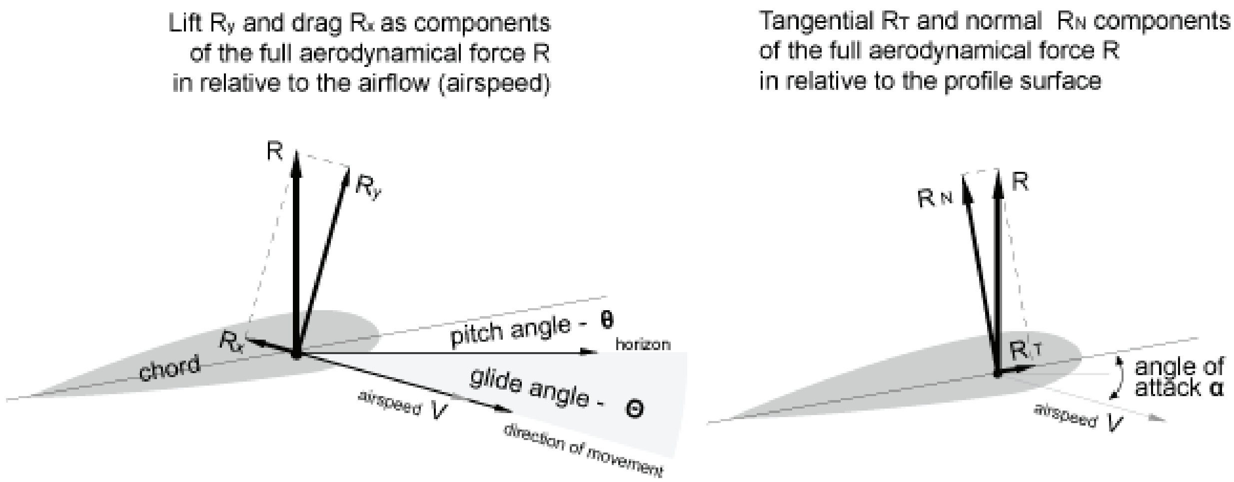


Figure 2-2

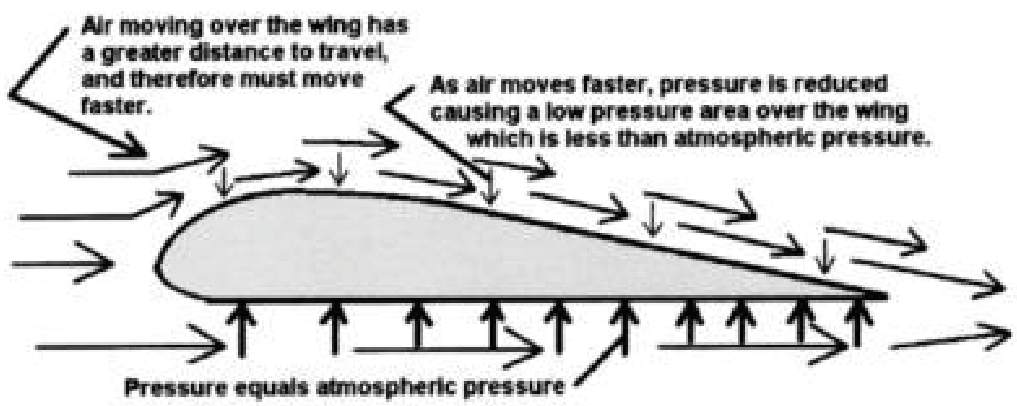
Aspect ratio is the wingspan divided by the average chord line.

Planform is the shape or form of a wing as viewed from above.

At any given time, there are four forces acting upon a glider. These forces are lift, weight (or gravity), drag and thrust. Lift is the key aerodynamic force that keeps objects in the air. It is the force that opposes weight; thus, lift helps to keep an aircraft in the air. Weight is the force that works vertically by pulling all objects, including aircraft, toward the center of the Earth. In order to fly an aircraft, something (lift) needs to press it in the opposite direction of gravity. The weight of an object controls how strong the pressure (lift) will need to be. Lift is that pressure. Drag is a mechanical force generated by the interaction and contract of a solid body, such as the lines and harnesses, with a fluid (liquid or gas). Finally, the thrust is the force that is generated by the running or towing of an aircraft in order for the aircraft to move forward from ground to air.

Bernoulli built his work off of that of Newton. In 1738, he published “Hydrodynamica”, his study in fluid dynamics, or the study of how fluids move. Bernoulli’s fluid experiment postulates how fluids behave when they are in motion. Air, like water, is a fluid; however, unlike water, which is a liquid, air is a gaseous substance. Air is considered a fluid because it flows and can take on different shapes. Bernoulli asserted in "Hydrodynamica" that as a fluid moves faster, it produces less pressure, and conversely, slower moving fluids produce greater pressure.

Then because of the shape of the paraglider or hang glider wing profile, called an airfoil, the air into which the wing flies is split at the wing's leading edge, passing above and below the wing at different speeds so that the air will reach the same endpoint along the trailing edge of the wing at the same time. In general, the wing's upper surface is curved so that the air rushing over the top of the wing speeds up and stretches out, which decreases the air pressure above the wing. In contrast, the air flowing below the wing moves in a straighter line, thus its speed and pressure remain about the same. Since high pressure always moves toward low pressure, the air below the wing pushes upward toward the air above the wing. The wing, in the middle, is then "lifted" by the force of the air perpendicular to the wing. The faster an airplane moves, the more lift there is. When the force of lift is greater than the force of gravity, the airplane is able to fly, and because of thrust, the airplane is able to move forward in flight. According to Newton's third law of motion, the action of the wings moving through the air creates lift.



Lift opposes the downward force of weight and is produced by the dynamic effects of the surrounding air- stream acting on the wing. Lift acts perpendicular to the flight path through the wing's center of lift. There is a mathematical relationship between lift, angle of attack, airspeed, altitude, and the size of the wing. In the lift equation, these factors correspond to the terms coefficient of lift, velocity, air density, and wing sur- face area. The relationship is expressed in Figure 2-3.

This shows that for lift to increase, one or more of the factors on the other side of the equation must increase. Lift is proportional to the square of the velocity, or airspeed, therefore, doubling airspeed quadruples the amount of lift if everything else remains the same. Small changes in airspeed create larger changes in lift. Likewise, if other factors remain the same while the coefficient of lift increases, lift also will increase. The coefficient of lift goes up as the angle of attack is increased. As air density increases, lift increases. However, you will usually be more concerned with how lift is diminished by reductions in air density on a hot day, or if you are operating at higher altitudes.

All wings produce lift in two ways:

Airfoil shape creating a higher velocity over the top of the wing and a lower velocity over the bottom of the wing with Bernoulli's venturi effect.

Downward deflection of airflow because of the curvature of the wing with the principle of Newton's Third Law of Motion: For every action, there is an equal and opposite reaction.

Both principles determine the lifting force. Review Chapter 2 in the *Pilot's Handbook of Aeronautical Knowledge* to understand Newton's laws of motion and force and Bernoulli's principle of pressure.

$$L = C_L V^2 \frac{\rho}{2} S$$

L = Lift

C_L = Coefficient of lift

(This dimensionless number is the ratio of lift pressure to dynamic pressure and area. It is specific to a particular airfoil shape, and below the stall, it is proportional to angle of attack.)

V = Velocity (Feet per second)

ρ = Air density (Slugs per cubic foot)

S = Wing surface area (Square feet)

Figure 2-3

Moment and Moment Arm

A study of physics shows that a body that is free to rotate will always turn about its CG. In aerodynamic terms, the mathematical measure of an aircraft's tendency to rotate about its CG is called a "moment." A moment is said to be equal to the product of the force applied and the distance at which the force is applied. (A moment arm is the distance from a datum [reference point or line] to the applied force.) For aircraft weight and balance computations, "moments" are expressed in terms of the distance of the arm times the aircraft's weight, or simply, inch-pounds.

Aircraft designers locate the fore and aft position of the aircraft's CG as nearly as possible to the 20 percent point of the mean aerodynamic chord (MAC). If the thrust line is designed to pass horizontally through the CG, it will not cause the aircraft to pitch when power is changed, and there will be no difference in moment due to thrust for a power-on or power-off condition of flight. Although designers have some control over the location of the drag forces, they are not always able to make the resultant drag forces pass through the CG of the aircraft. However, the one item over which they have the greatest control is the size and location of the tail. The objective is to make the moments (due to thrust, drag, and lift) as small as possible and, by proper location of the tail, to provide the means of balancing an aircraft longitudinally for any condition of flight.

The pilot has no direct control over the location of forces acting on the aircraft in flight, except for controlling the center of lift by changing the AOA. The pilot can control the magnitude of the forces. Such a change, however, immediately involves changes in other forces. Therefore, the pilot cannot independently change the location of one force without changing the effect of others. For example, a change in airspeed involves a change in lift, as well as a change in drag and a change in the up or down force on the tail. As forces such as turbulence and gusts act to displace the aircraft, the pilot reacts by providing opposing control forces to counteract this displacement.

Drag

Drag is the resistance to forward motion through the air. Drag opposes thrust.

Aerodynamic drag comes in two forms:

Induced drag: a result of the wing producing lift;
Parasite drag: resistance to the airflow from harnesses, its occupants, suspension lines from the wing, interference drag from objects in the airstream, and skin friction drag of the wing.

Induced drag is the result of lift, and its amount varies as discussed above for lift. Induced drag creates organized circular vortices off the wing tips that generally track down and out from each wingtip. *[Figure 2- 4]* This is true for all aircraft that use wings, weight-shift control and fixed wing aircraft. The bigger and heavier the aircraft, the greater and more powerful the wingtip vortices will be. This organized swirling turbulence is an important factor to understand for flight safety. Refer to Section 7-3 of the Aeronautical Information Manual (AIM) or Chapter 12 of the Pilot's Handbook of Aeronautical Knowledge (FAA-H- 8083-25) for additional discussion.

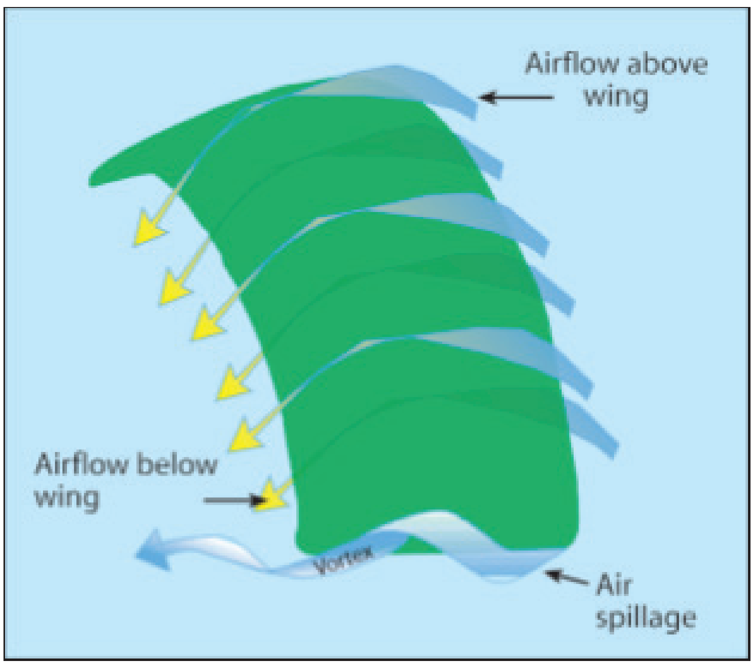


Figure 2-4

Parasite drag is caused by the friction of air moving over the structure. Just as with lift, parasite drag in- creases as the surface area of the aircraft increases and dramatically increases as airspeed increases, at the square of the velocity. Therefore, doubling the airspeed will quadruple your parasite drag.

Induced and parasitic drag have opposite effects as angle of attack decreases and speed increases. Note the total drag. It is high at the slowest air speeds at high angles of attack near the stall, decreases to the lowest at the most efficient airspeed, and then progressively increases as the speed increases.

Ultralight wings are typically designed to fly at a speed generally above lowest overall total drag. Too slow, and the wing would be near its critical angle of attack. Too fast, and the power to maintain level flight or climb would be excessive. The manufacturer determines the speed range of the wing based on the weight range, and the resultant location on the total drag diagram. *[Figure 2-5]*

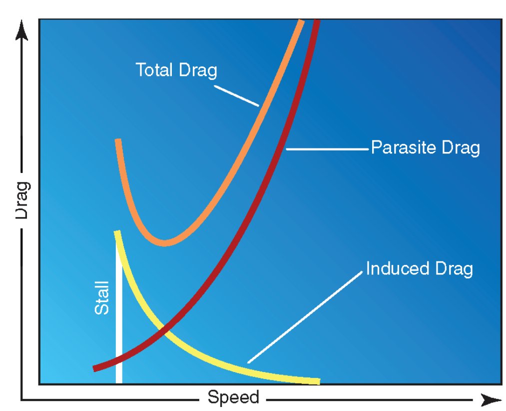


Figure 2-5

Center of Gravity

The center of gravity (CG) is the theoretical point of concentrated weight of the aircraft. The most obvious difference in the center of gravity for a ultralight is the vertical position compared to an airplane, as it is much lower than the wing. The Pilot's Handbook of Aeronautical Knowledge accurately states the center of gravity is generally in the vertical center of the fuselage. The same is true for the ultralight. However, the ultralight wing is high above the fuselage creating the unique pendulum effect flying characteristics of the paraglider and to a more limited extent the hang glider.

Ground Effect

Ground effect is the interference of the ground with the airflow and turbulence patterns created by the wing. The most apparent indication from ground effect is the unexpected lift given to an aircraft as it flies close to the ground — normally during takeoffs and landings.

Stalls: Exceeding the Critical Angle of Attack

The critical angle of attack is the angle of attack at which a wing stalls regardless of airspeed, flight attitude, or weight. The drawings in Figure 2-6 show airflow over a typical rectangular PPC wing. The first shows a laminar, smooth, lift-generating airflow—one that is typical when the angle of attack is within the flight range. The second depicts an exceeded angle of attack, turbulence and loss of the lifting force. *[Figure 2-6]*

Unlike a fixed-wing aircraft that takes constant awareness of angle of attack to prevent a stall, paragliders and hang gliders are designed by the manufacturers to maintain a specified range of angle of attack and air- speeds. It is resistant to stalls because for all practical purposes, it is designed to fly at a constant normal op erating range. This range is maintained if the operator flies within the operating limitations specified in the manufacturer's manual. Flying the wings within the limitations specified in by the manufacturers and avoiding turbulence means you will not exceed the critical angle of attack and stall the wing.

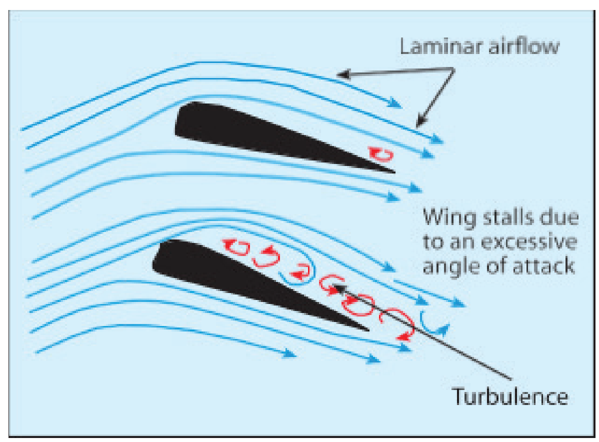


Figure 2-6

Stability

Stability is the inherent quality of an aircraft to correct for conditions that may disturb its equilibrium and to return to or to continue on the original flight path. It is primarily an aircraft design characteristic. The flight paths and attitudes aircraft flies are limited by the aerodynamic characteristics of the aircraft, its propulsion system, and its structural strength. These limitations indicate the maximum performance and maneuverability of the aircraft. If the aircraft is to provide maximum utility, it must be safely controllable to the full extent of these limits without exceeding the pilot's strength or requiring exceptional flying ability. If an aircraft is to fly straight and steady along any arbitrary flight path, the forces acting on it must be in static equilibrium. The reaction of any body when its equilibrium is disturbed is referred to as stability. The two types of stability are static and dynamic.

Static Stability

Static stability refers to the initial tendency, or direction of movement, back to equilibrium. In aviation, it refers to the aircraft's initial response when disturbed from a given pitch, yaw, or bank.

Positive static stability—the initial tendency of the aircraft to return to the original state of equilibrium after being disturbed. *[Figure 2-7]*

Neutral static stability—the initial tendency of the aircraft to remain in a new condition after its equilibrium has been disturbed. *[Figure 2-7]*

Negative static stability—the initial tendency of the aircraft to continue away from the original state of equilibrium after being disturbed. *[Figure 2-7]*

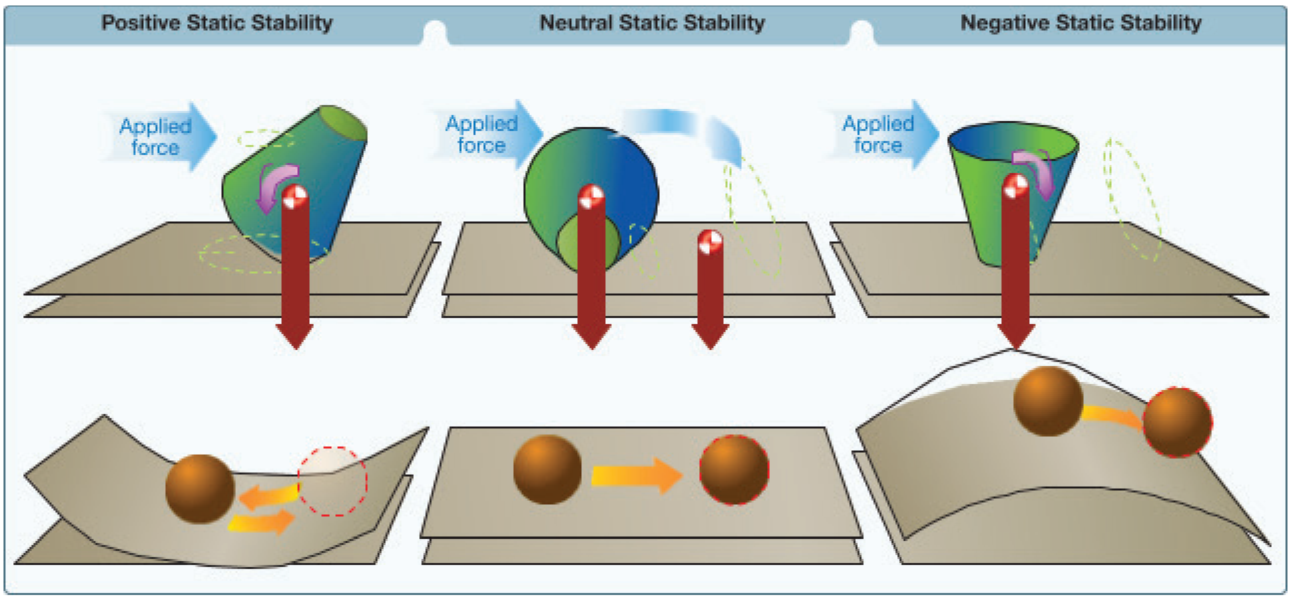


Figure 2-7

Dynamic Stability

Static stability has been defined as the initial tendency to return to equilibrium that the aircraft

displays after being disturbed from its trimmed condition. Occasionally, the initial tendency is different or opposite from the overall tendency, so a distinction must be made between the two. Dynamic stability refers to the aircraft response over time when disturbed from a given pitch, yaw, or bank.

This type of stability also has three subtypes *[Figure 2-8]* **:**

Positive dynamic stability—over time, the motion of the displaced object decreases in amplitude and, because it is positive, the object displaced returns toward the equilibrium state.

Neutral dynamic stability—once displaced, the displaced object neither decreases nor increases in amplitude. A worn automobile shock absorber exhibits this tendency.

Negative dynamic stability—over time, the motion of the displaced object increases and becomes more divergent

Stability in an aircraft affects two areas significantly:

Maneuverability—the quality of an aircraft that permits it to be maneuvered easily and to withstand the stresses imposed by maneuvers. It is governed by the aircraft's weight, inertia, size and location of flight controls, structural strength, and powerplant. It too is an aircraft design characteristic.

Controllability—the capability of an aircraft to respond to the pilot's control, especially with regard to flight path and attitude. It is the quality of the aircraft's response to the pilot's control application when maneuvering the aircraft, regardless of its stability characteristics.

Longitudinal Stability (Pitching)

In designing an aircraft, a great deal of effort is spent in developing the desired degree of stability around all three axes. But longitudinal stability about the lateral axis is considered to be the most affected by certain variables in various flight conditions.

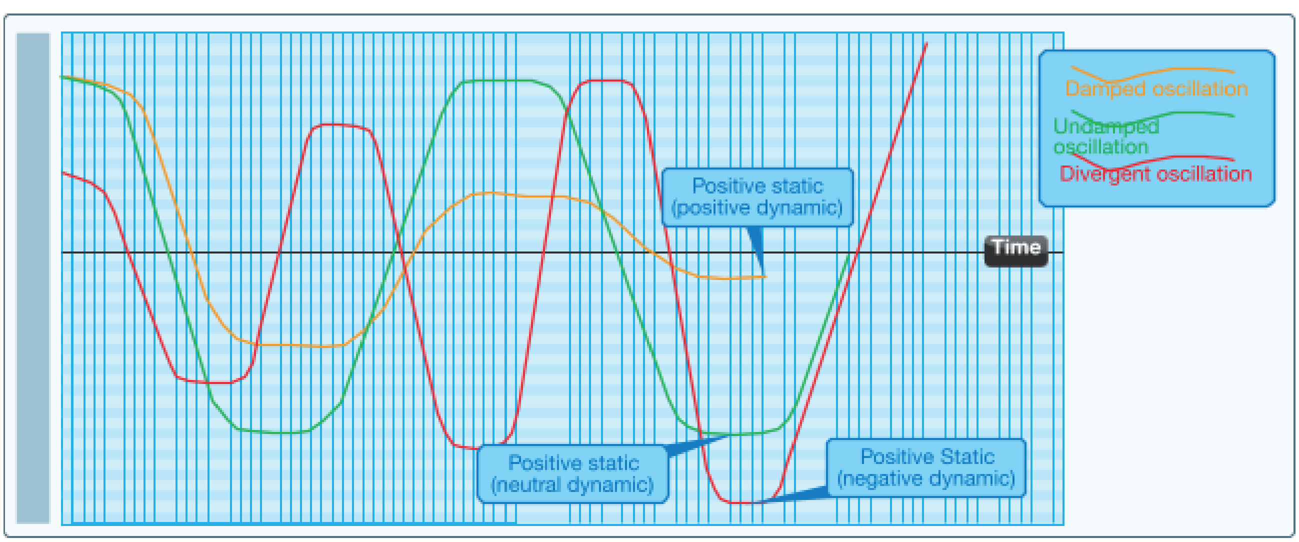
Longitudinal stability is the quality that makes an aircraft stable about its lateral axis. It involves the pitching motion as the aircraft's nose moves up and down in flight. A longitudinally unstable aircraft has a tendency to dive or climb progressively into a very steep dive or climb, or even a stall. Thus, an aircraft with longitudinal instability becomes difficult and sometimes dangerous to fly.

Static longitudinal stability, or instability in an aircraft, is dependent upon three factors:

Location of the wing with respect to the CG
Location of the horizontal tail surfaces with respect to the CG
Area or size of the tail surfaces

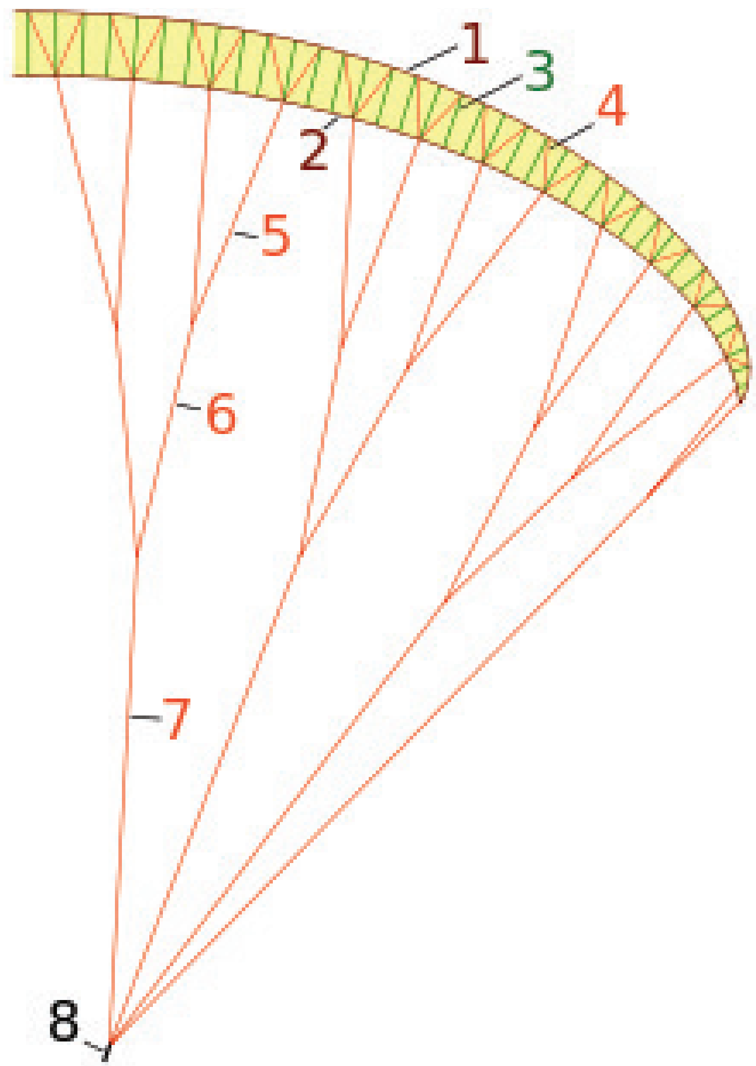
In analyzing stability, it should be recalled that a body free to rotate always turns about its CG.

To obtain static longitudinal stability, the relation of the wing and tail moments must be such that, if the moments are initially balanced and the aircraft is suddenly nose up, the wing moments and tail moments change so that the sum of their forces provides an unbalanced but restoring moment which, in turn, brings the nose down again. Similarly, if the aircraft is nose down, the resulting change in moments brings the nose back up.



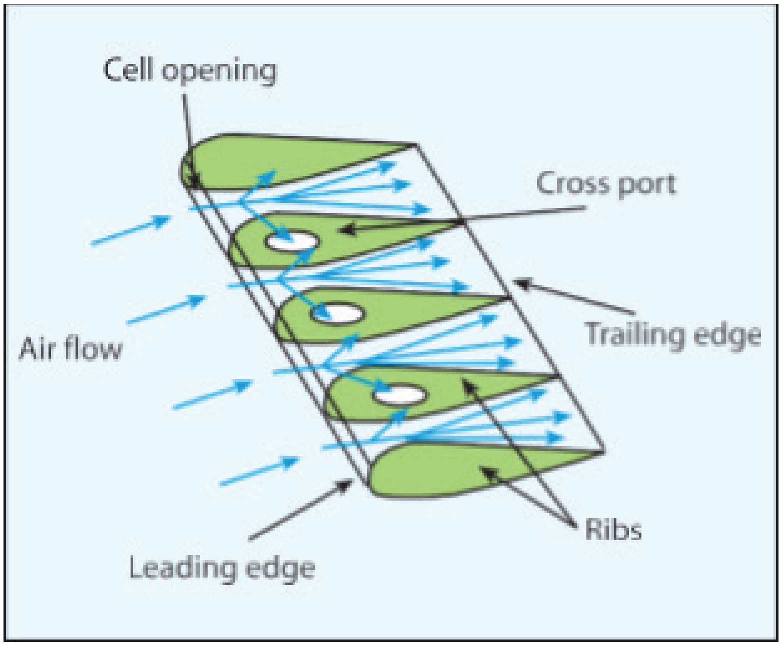
Chapter Three

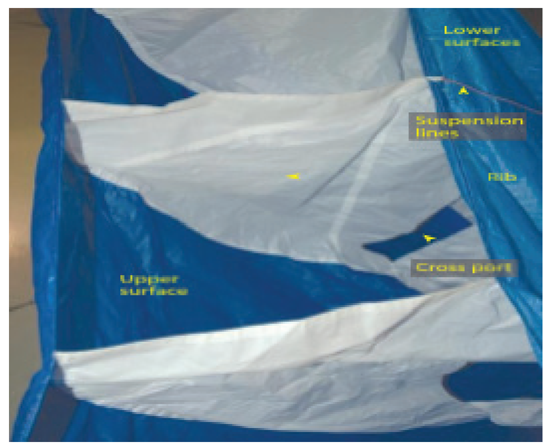
Equipment



Transverse cross section showing parts of a paraglider:

1. upper surface
2. lower surface
3. rib
4. diagonal rib
5. upper line cascade
6. middle line cascade
7. lower line cascade
8. risers





The paraglider wing or canopy is usually what is known in engineering as a ram-air airfoil. Such wings comprise two layers of fabric that are connected to internal supporting material in such a way as to form a row of cells. By leaving most of the cells open only at the leading edge, incoming air keeps the wing inflated, thus maintaining its shape. When inflated, the wing's cross-section has the typical teardrop aerofoil shape. Modern paraglider wings are made of high-performance non-porous materials such as ripstop polyester[12] or nylon fabric.[note 1]

In some modern paragliders (from the 1990s onwards), especially higher-performance wings, some of the cells of the leading edge are closed to form a cleaner aerodynamic profile. Holes in the internal ribs allow a free flow of air from the open cells to these closed cells to inflate them, and also to the wingtips, which are also closed.[13]

The pilot is supported underneath the wing by a network of suspension lines. These start with two sets of risers made of short (40 cm (16 in)) lengths of strong webbing. Each set is attached to the harness by a carabiner, one on each side of the pilot, and each riser of a set is generally attached to lines from only one row of its side of wing. At the end of each riser of the set, there is a small delta maillon with a number (2–5) of lines attached, forming a fan. These are typically 4–5 m (13–16 ft) long, with the end attached to 2–4 further lines of around 2 m (6.6 ft) m, which are again joined to a group of smaller, thinner lines. In some cases this is repeated for a fourth cascade.

The top of each line is attached to small fabric loops sewn into the structure of the wing, which are generally arranged in rows running span-wise (i.e., side to side). The row of lines nearest the front are known as the A lines, the next row back the B lines, and so on.[14] A typical wing will have A, B, C and D lines, but recently, there has been a tendency to reduce the rows of lines to three, or even two (and experimentally to one), to reduce drag.
Paraglider lines are usually made from UHMW polythene or aramid.[14] Although they look

rather slender, these materials are immensely strong. For example, a single 0.66 mm-diameter line (about the thinnest used) can have a breaking strength of 56 kgf (550 N).[15]

Paraglider wings typically have an area of 20–35 square metres (220–380 sq ft) with a span of 8–12 metres (26–39 ft) and weigh 3–7 kilograms (6.6–15.4 lb). Combined weight of wing, harness, reserve, instruments, helmet, etc. is around 12–22 kilograms (26–49 lb).

The glide ratio of paragliders ranges from 8.3 for recreational wings to about 10.3 for modern competition models,[16] reaching in some cases up to 11.[17] For comparison, a typical skydiving parachute will achieve about 3:1 glide. A hang glider ranges from 9.5 for recreational wings to about 16.5 for modern competition models. An idling (gliding) Cessna 152 light aircraft will achieve 9:1. Some sailplanes can achieve a glide ratio of up to 72:1.

The speed range of paragliders is typically 20–75 kilometres per hour (12–47 mph), from stall speed to maximum speed. Beginner wings will be in the lower part of this range, high-performance wings in the upper part of the range.[note 2]

For storage and carrying, the wing is usually folded into a stuff sack (bag), which can then be stowed in a large backpack along with the harness. For pilots who may not want the added weight or fuss of a backpack, some modern harnesses include the ability to turn the harness inside out such that it becomes a backpack.

Paragliders are unique among human-carrying aircraft in being easily portable. The complete equipment packs into a rucksack and can be carried easily on the pilot's back, in a car, or on public transport. In comparison with other air sports, this substantially simplifies travel to a suitable takeoff spot, the selection of a landing place and return travel.

Tandem paragliders, designed to carry the pilot and one passenger, are larger but otherwise similar. They usually fly faster with higher trim speeds, are more resistant to collapse, and have a slightly higher sink rate compared to solo paragliders.

A pilot with harness (light blue), performing a reverse launch

Harness

The pilot is loosely and comfortably buckled into a harness, which offers support in both the standing and sitting positions. Most harnesses have foam or airbag protectors underneath the seat and behind the back to reduce the impact on failed launches or landings. Modern harnesses are designed to be as comfortable as a lounge chair in the sitting or reclining position. Many harnesses even have an adjustable lumbar support. A reserve parachute is also typically connected to a paragliding harness.

Harnesses also vary according to the need of the pilot, and thereby come in a range of designs, mostly:

- training harness for beginners
- pax harness for tandem passengers that often also doubles as a training harness
- XC harness for long-distance cross-country flights
- all-round harness for basic to intermediate pilots
- pod harness for intermediate to pro pilots that focus on XC
- acro harnesses, special designs for acrobatic pilots
- kids tandem harnesses are also now available with special child-proof locks

Instruments for Ultralight Aviation

Most pilots use variometers, radios, and, increasingly, GPS units when they are flying.

Variometer

Main article: Variometer

The main purpose of a variometer is in helping a pilot find and stay in the "core" of a thermal to maximize height gain and, conversely, to indicate when a pilot is in sinking air and needs to find rising air. Humans can sense the acceleration when they first hit a thermal, but cannot detect the difference between constant rising air and constant sinking air. Modern variometers are capable of detecting rates of climb or sink of 1 cm per second. A variometer indicates climb rate (or sink-rate) with short audio signals (beeps, which increase in pitch and tempo during ascent, and a droning sound, which gets deeper as the rate of descent increases) and/or a visual display. It also shows altitude: either above takeoff, above sea level, or (at higher altitudes) flight level.

Radio

Radio communications are used in training, to communicate with other pilots, and to report where and when they intend to land. These radios normally operate on a range of frequencies in different countries—some authorized,[18][19] some illegal but tolerated locally. Some local authorities (e.g., flight clubs) offer periodic automated weather updates on these frequencies. In rare cases, pilots use radios to talk to airport control towers or air traffic controllers. Many pilots carry a cell phone so they can call for pickup should they land away from their intended point of destination.

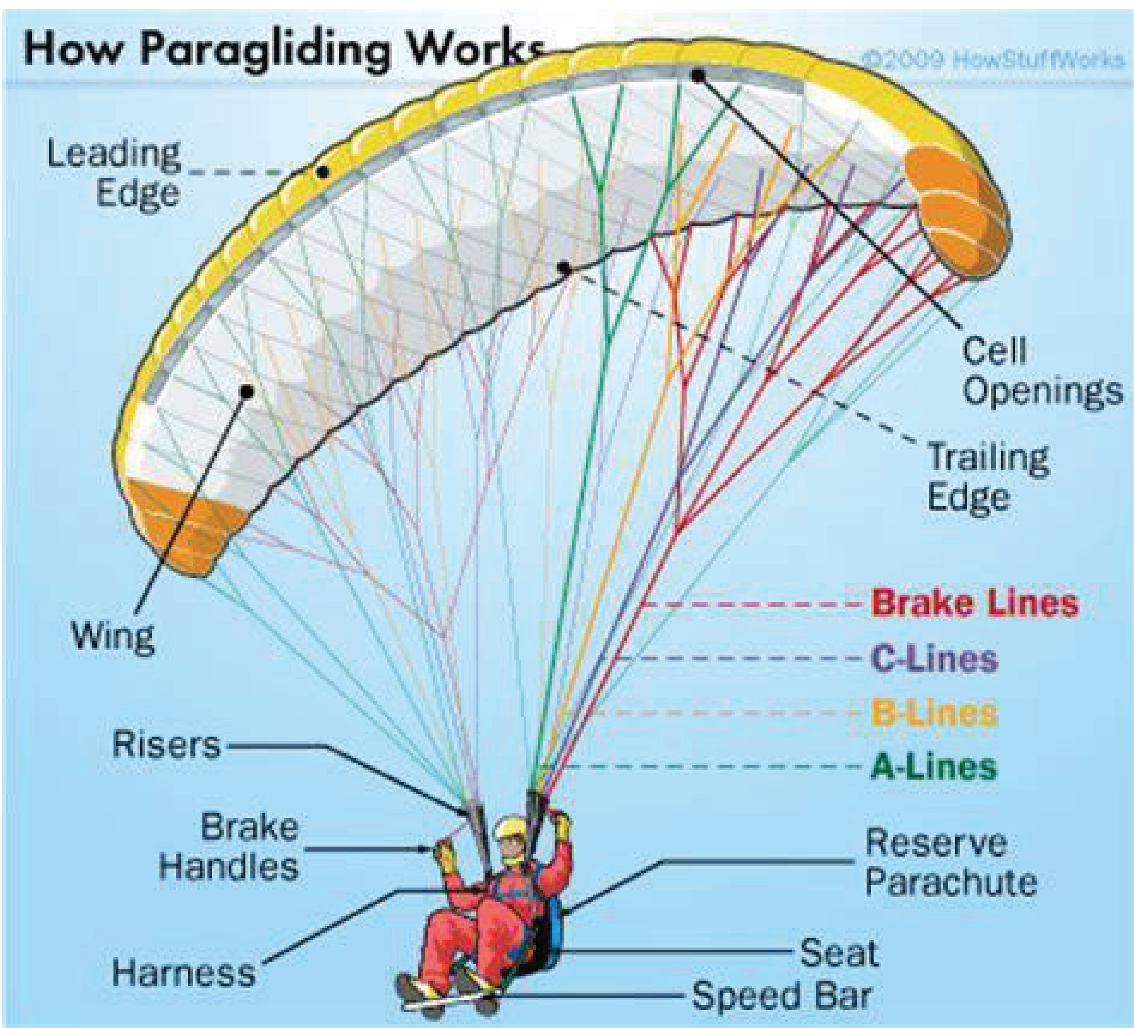
GPS

GPS is a necessary accessory when flying competitions, where it has to be demonstrated that way-points have been correctly passed. The recorded GPS track of a flight can be used to analyze flying technique or can be shared with other pilots. GPS is also used to determine drift due to the prevailing wind when flying at altitude, providing position information to allow restricted airspace to be avoided and identifying one's location for retrieval teams after landing out in unfamiliar territory. GNSS is integrated with some models of variometer. This is not only more convenient, but also allows for a three-dimensional record of the flight. The flight track can be used as proof for record claims, replacing the old method of photo documentation.

Increasingly, smart phones are used as the primary means of navigation and flight logging, with several applications available to assist in air navigation. They are also used to co-ordinate tasks in competitive paragliding and facilitate retrieval of pilots returning to their point of launch. External variometers are typically used to assist in accurate altitude information.

Garmin InReach/SPOT

Personal locater beacons utilizing satellite relays are critical for safety during cross country flying and/or paragliding competitions.



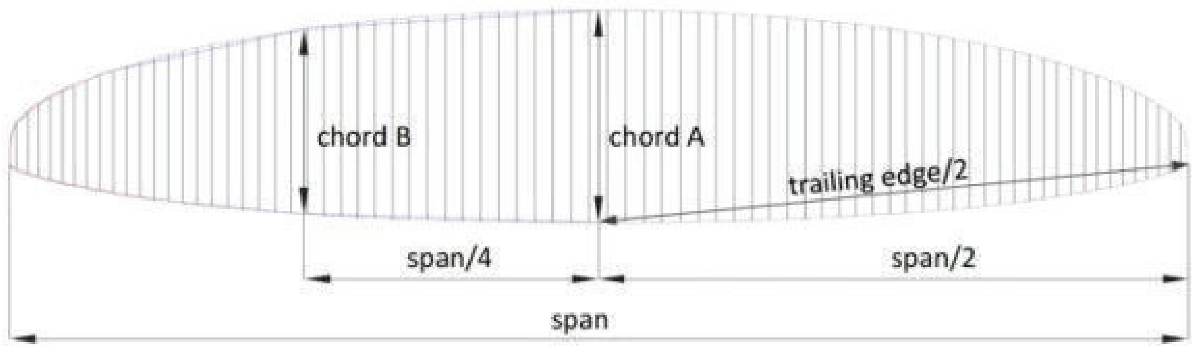


Figure 1: Canopy dimension measurements

Number of Cells

Number of individual cell openings a glider has. Typically, the higher the number the higher the performance and more difficult to fly.

Projected Area (m^2)

This is the size of the shadow a wing will cast on the ground. This area measurement considers the chord, trim, and span.

Flat Area (m^2)

This is the area calculation of the wing when laid on the ground flat.

Projected Aspect Ratio

The wingspan divided by the chord. Typically, safe wings have a low aspect ratio and performance wings have a high aspect ratio.

Root Chord (m)

The width of the canopy from center cell front to center cell back.

Certified Weight Range (kg)

The weight range the manufacturer utilized with the testing body to certify the glider to respond to events as tested by the EN.

Recommended Flying Weight (kg)

The weight the manufacturer recommends for flying the wing at its best performance.

All up weight/ Clip in Weight (kg)

A pilot's flying weight that includes everything that would launch including the paraglider. So a pilots all up weight is their weight, and everything that is in their backpack while heading to launch that they will launch with.

EN Certification

Gliders are certified to recover from a set standard of manueavers peformed by a testing house in France called Air Turqoise. The reaction of the canopy will determine what category the glider will fall into and which pilot level it will be sold to. The manufacturers develop gliders by performance characteristics knowing that once it passes the tests it will be available and desired by the corresponding pilot demography that desire either safety, performance, or a blend of the two.

Tandem Spreader Bars

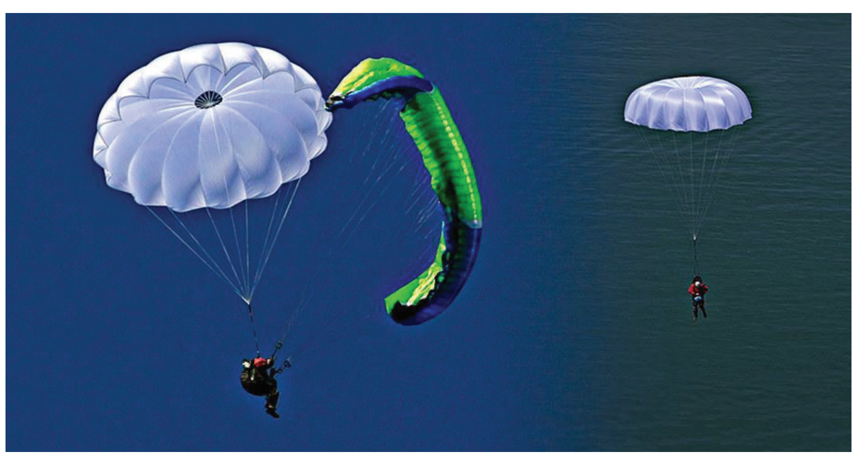
Once you are hooked in to your harness by your instructor and they have double checked all your buckles they will give you a brief introduction to foot launching a paraglider. The key is to listen and do what the instructor says. Some key points that may come into play depending on where you are launching are to keep moving your feet until your instructor tells you to stop. You will be well off the ground and running in place before they tell you it is ok to get into your harness. Don't sit down until you are instructed to do so from your pilot. Wear sensible running or hiking shoes with good ankle support. You will be connected to your instructor by tandem spreader bars (pictured below). The spreader bars attach the canopy to both harnesses, the pilots to each other, and the reserve parachute to a point that will be best for the pilots should a reserve be deployed. Once you are airborne you will need to put your arms behind the spreader bars and push yourself into your harness. Your instructor will guide you through these easy steps.

Reserves

The two main factors in reserve parachute performance are sink rate and stability. A reserve parachute with an acceptable theoretical sink rate can still deliver the pilot to the ground with a lot of force if the pilot hits while swinging. The increased stability of square parachutes delivers higher performance than traditional round parachutes. Reserves are typically certified by the EN and LTF to EN 12491 and LTF 91/09 standards.

Once a reserve is deployed the pilot must disable the main canopy to prevent down planning and/or competing forces from increasing their decent rate. A pilot must also be careful to always through their reserve to open air to avoid entanglement between the two canopies, or even worse a Pacman like situation where the main canopy gobbles the reserve up as it pivots around the pilot at a fast rate of speed.

Round reserves, or Pull Down Apex (PDA), reserves are still manufactured and used. A simple design that works if it’s big enough to give a decent descent. This is the ‘traditional’ tried and trusted design, and is the most affordable option. Pay particular attention to the size (area in m^2) as one of the main factors which determines the ‘sink rate’ of a reserve is the load per square meter.



A Rogallo style steerable reserve is also an option which when opened has brake toggles that can control descent direction to some extent. After having thrown a non-steerable reserve and contemplated the many horrors below, pilots often decide to buy a Rogallo style reserve. Many acro and test pilots swear by them, because if you deploy high enough and control or cutaway the main, you can choose where you land. They offer the best descent rate (due to having an aero foil), fastest opening speed and the most landing options due to being steerable. All reserves present a risk of down-planning if you do not disable the paraglider. Some Rogallos have an increased risk of down-planning due to their gliding tendency, but this is mitigated by having a very large surface area that deploys in a slowed state (High Adventure Beamer 3). If you can get control of your main paraglider (B-stall, C-stall, wrapped brakes or pulled in wing) it is not necessary to cut-away, but you can do so if your harness is equipped with quick-out karabiners and speed bar pins (or a hook knife). That produces increased gliding ability, removes twists and reduces the risk of the wing tangling with the reserve. You can steer yourself into clear airflow and land into wind, reducing ground speed and landing impact. They are more expensive and more difficult to pack correctly.

Paraglider Risers

Riser design has come a long way in the last ten years. Wings went from having four risers, to three risers, then in 2010 Ozone Paragliders reduced the risers to two thus reducing drag significantly and enabling more direct control while in accelerated flight. The two riser performance trickled down to the three riser gliders which are more stable and easier to fly due to internal construction developments and riser evolution to increase control authority at speed. Thus a hybrid riser system [Figure 3-6] highlights rear riser control handles that previously did not exist.

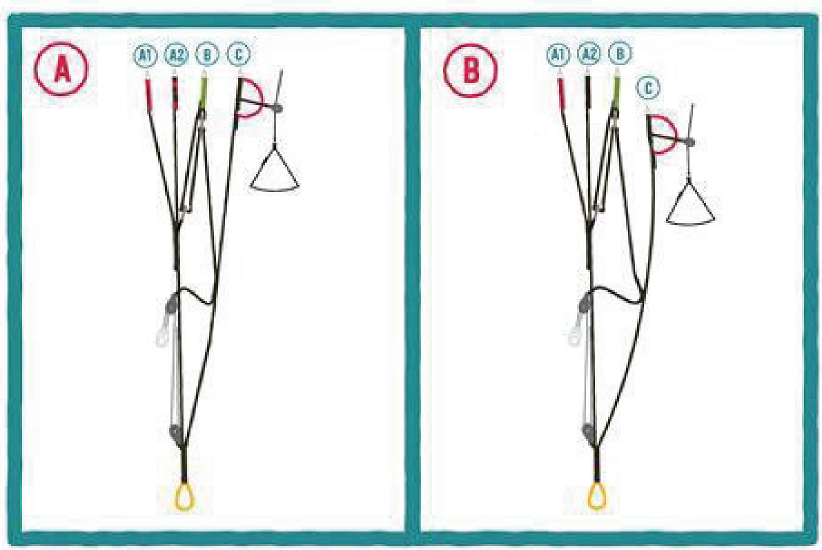
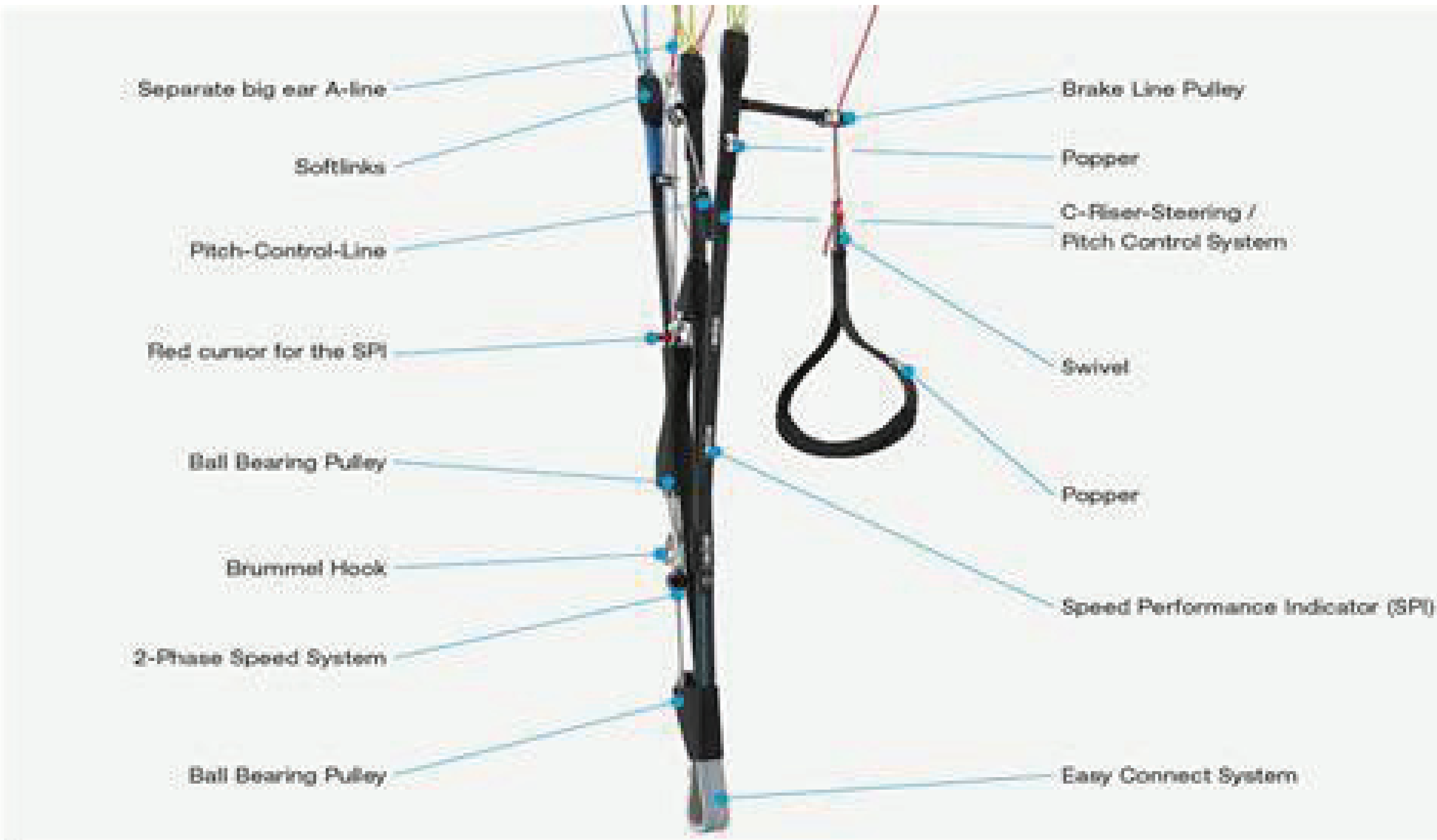


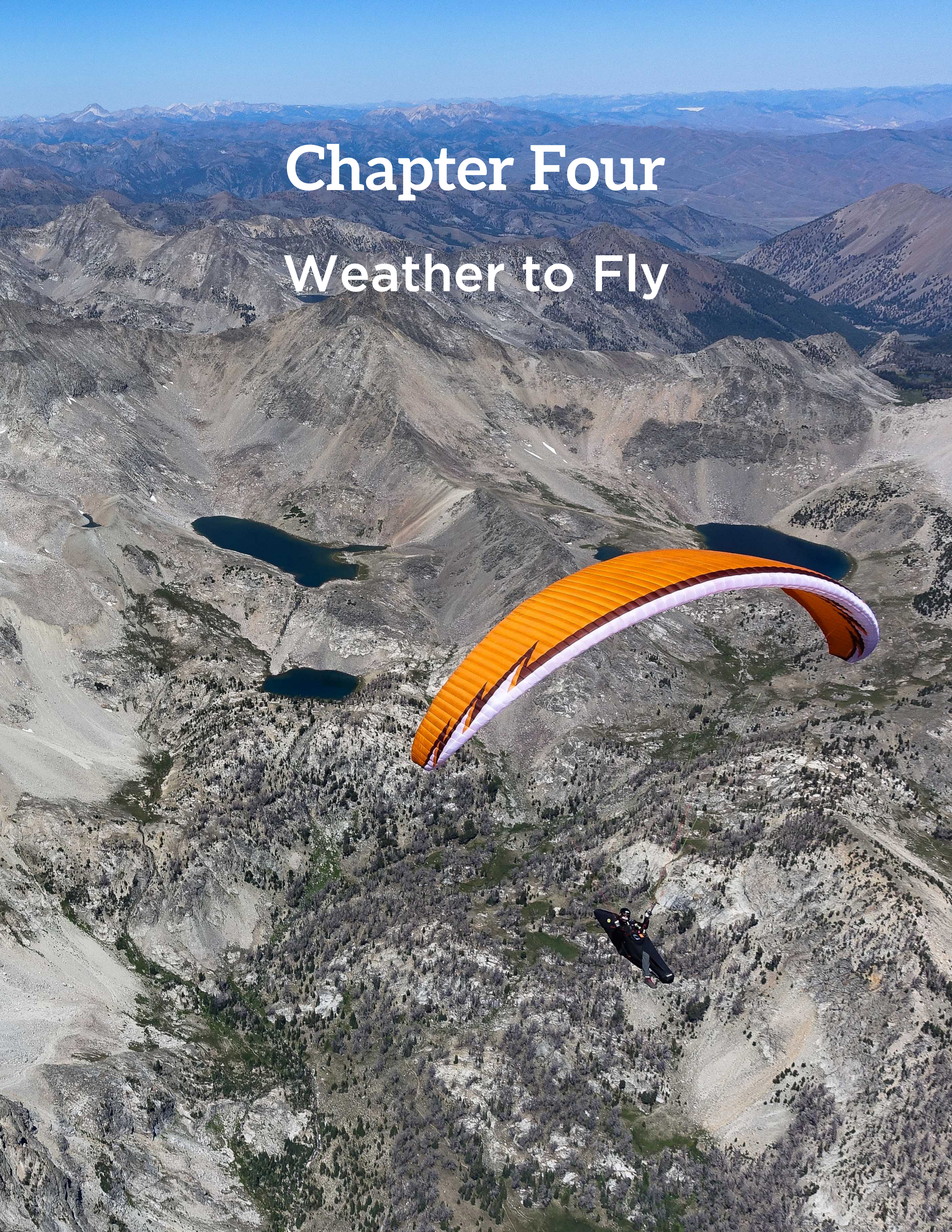
Figure 3-6



Shown is a classic three riser system which makes up the bulk of gliders made in 2022.

Chapter Four

Weather to Fly



Structure of the Atmosphere

The atmosphere is an envelope of air that surrounds the Earth and rests upon its surface. It is as much a part of the Earth as is land and water. However, air differs from land and water in that it is a mixture of gases. It has mass, weight, and indefinite shape. Air, like any other fluid, can flow and change its shape when subjected to even minute pressures because of the lack of strong molecular cohesion. For example, gas will completely fill any container into which it is placed, expanding,   or contracting to adjust its shape to the limits of the container. The atmosphere is composed of 78 percent nitrogen, 21 percent oxygen, and 1 percent other gases, such as argon or helium. Most of the oxygen is contained below 35,000 feet altitude.
There are many ways to see if the day will be safe for flying. The number one variable is wind speed and the second is direction. There are also great subscription websites specifically for soaring including www.xcskies.com, www.skysight.io, and your local NOAA Aviation Forecast Discussion. A good starting point for the new pilot is to learn what a Skew T can tell you from real data collected the actual day you want to fly.

Skew T's – How to Read Them by Jim Martin (UP) Finger Lakes Soaring Club, Dansville, NY 2015
Compiled, Condensed, edited from many sources

Rising Air is our Engine!

Thermals & Instability
Sunlight, passes through the air without heating it, until it strikes something that absorbs it, and converts it to heat - such as a dark, plowed field, pavement, or exposed sunward facing rock face. Chlorophyll in grass and trees absorbs the sunlight perfectly without converting it to heat. Differential heating of the ground produces thermals. Yet, unless the air above it is cooler, it will not rise. How much cooler – determines how fast it can rise.
This is called "Instability" or "Unstable" Air. It doesn't want to stay still! The air above is not holding it down (Stable).

Soundings
In the past, Radiosonde Balloons were sent aloft every morning at 0600 AM from Buffalo and other locations to record the temperature, dewpoint, wind direction and speed – at each altitude as it rose through the airmass. Now, satellites and can be used to measure, and computer models used to predict the characteristics of the Airmass over any location. The plots of these readings are called Soundings, and the graph is called a Skew-T diagram – due to the fact the same temperature line is plotted "Skewed" to the right". These plots present a tremendous amount of useful information to us as Soaring Pilots.

Motivation

Once you learn how to read these plots, you will be able to determine;

Whether there is an Inversion that needs to be broken/mixed up to begin soaring
Trigger Temperature – what surface temperature thermals will start
What the max temperature can be expected for the day
When that temperature is reached – how high the thermals will go
Whether clouds will form, what altitudes, and how thick the layers may be
Wind directions and speed at various altitudes-where to look for lift close to the ground/ near clouds
If there will overdevelopment, thunderstorms, or rain
Overall – how good or bad the day will be, and what needs to happen to change it from what is forecast

Skew-T diagrams look pretty forbidding until they are explained to you, but, hopefully, I will provide enough guidance to enable you to take a quick look at them and draw conclusions about the kind of a soaring day is expected.

Where to get the Sounding Data

One of the best Websites is Bill Moninger's FSL website Interactive Skew-T diagram. You will have to download and enable JAVA to view. If you are unable to use JAVA, use the HML5 button. If you enter the airport identifier, and the time you are interested in, it gives you a plot for that location. By dwelling the mouse pointer over the expected max temperature for the day at the surface altitude, and then click, it generates an additional plot that depicts the excess energy and condensation level, and convective levels expected.

Soaring Chart Forecast Websites

My Favorite website is XCSkies which presents data from these plots and presents soaring forecasts. This website is updated throughout the day and is produced closer to the actual time we might be soaring.

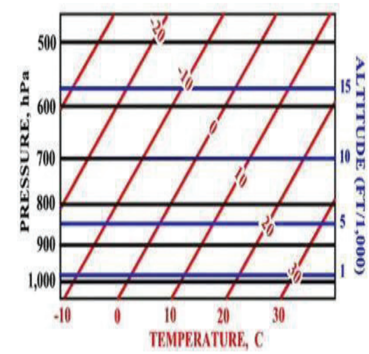
Another useful Soaring website which also uses Skew-T information, yet produces multiple forecast maps: Dr. Jack's BLIPMAPS. Both present charts, without your needing to interpret the Soundings info, yet, remember, you need to understand – and be advised- that pretty though they be, if the underlying numerical model is wrong, and it sometimes is, the forecast will be wrong. When you understand what the skew-T is showing, you are in a position to critically assess these forecast charts.

Parenthetically I note that although these diagrams are ideal as thermal soaring forecasts, they were developed as an aid by the government in forecasting convective storms. The enormous effort which goes into gathering the data, then accurately modeling it- is driven by the destructive potential of cyclones, hurricanes, and thunderstorms- not by our desire to have good soaring forecasts.

Design of the Skew-T Diagram

Skew-T's are graphs which display temperature and dewpoint data vertically in the earth's atmosphere. The constant temperature lines are "skewed" to the right as it goes up in altitude/pressure level. Additional lines are superimposed on the graphs, which are based on calculations which determine other valuable information we need to determine. These additional lines (dry adiabats, saturated adiabats, constant mixing ratio) were calculated by thermodynamic equations. Thankfully, we don't need to worry about the equations, and don't need to do any math. We do however need to understand what they represent.

Temperature and Pressure Lines

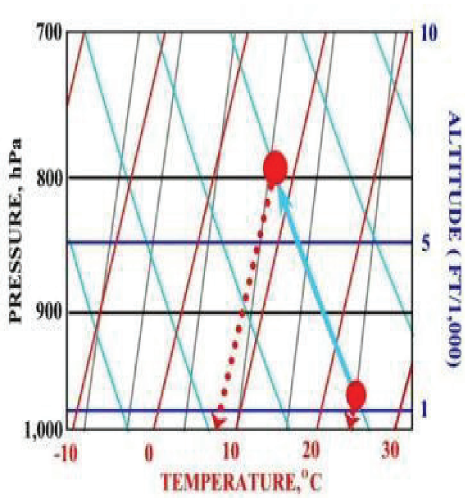


The constant temperature lines are angled ("skewed") vertically to the right, and the decreasing pressure scale (altitude) is displayed horizontally /logarithmically. Therefore, the official name is "Skew-T logP Diagram. These choices make the variables we will examine – easier to display by other lines. That is convenient when making extrapolations on a graph. For clarity, pressure altitude lines are added to the right. These altitudes maybe in feet above sea-level or Kilometers, depending on which agency produces the diagram.

Rate of Cooling (Lapse Rate)

Air, as it ascends, expands, and because of this - it cools. Air, at the surface, holds a certain amount of suspended water vapor. As a parcel of air ascends, it cools at a given rate-called the Dry Adiabatic Lapse Rate (DALR) - until the air is so cold it can no longer keep the water vapor suspended. A cloud forms. It then ascends at the Wet, Saturated, or Moist Adiabatic Lapse Rate (SALR) . "Adiabatic" is a thermodynamic term meaning "rate at which temperature changes".

Dry Adiabatic Lines



The dry adiabatic lines depict what happens to the temperature of a parcel of air as it rises before it becomes saturated (100% humidity). Because the density, and hence the buoyancy of air, depends upon its temperature and how much water vapor is suspended in it.

This is the first example of "calculating lines". They are depicted in cyan in this simplified skew-T to which are added only the dry adiabats. It depicts a red spherical bubble of air at the surface (in this case at 1,200 ft MSL and at a temperature of 23ºC) and tells us what happens when the bubble of air rises to about 6,000 ft MSL. This red spherical bubble is a simple model for of a thermal. As it rises, it cools, and the precise amount of cooling is determined by following the dry adiabatic lines. Note- because the temperature axis is skewed, care must be taken in choosing the correct temperature. The red dotted arrow shows how the temperature is derived by projecting down from that altitude to the surface temperature. Note - often there is no dry adiabat coinciding with the surface temperature (fog) - when this happens it is easy enough to construct it for prediction purposes.

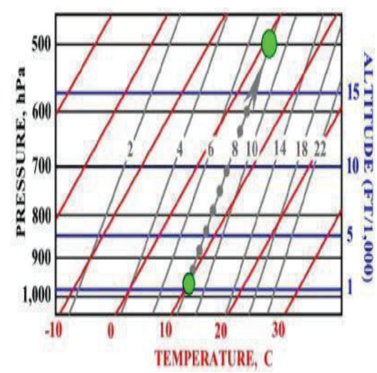
By the time the bubble is at 6,000 ft it has cooled to 8ºC and has expanded by about 20%. The cooling is driven by the expansion of the bubble. As it rises the pressure of the surrounding air decreases and the bubble expands and does work pushing away the enveloping air. It is this work, achieved by tapping the internal energy of the bubble, which is responsible for the cooling.

An adiabatic process is one which takes place without exchange of heat with the surroundings - so, in assuming an adiabatic process, we are assuming that the parcel of air maintains its identity and does not mix with the air through which it is moving. This is an acceptable assumption, at least in the sense that it yields useful and consistent results.

“Dry” in DALR does not mean quite what it says, since air is never dry. Specifically, it means that no condensation has yet occured. Notice – this rate is slightly more than 3ºC per 1000ft. When condensation does occur, the Saturated Adiabatic Lapse Rate (SALR) takes over. We will consider the SALR lines latter when considering what goes on above cloudbase.

Lines of Constant Mixing Ratio (Cloudbase)

We started with the empty skew-T logP graph to which we added dry adiabats. To describe what happens to the dewpoint of a rising parcel of air we need to add more lines - the lines of constant mixing ratio (depicted here by gray lines with the number of grams of water the parcel can hold when saturated). Where these lines intersect with the DALR determine where the water vapor will condense and form a cloud. We know from the dry adiabats how quickly the temperature cools with ascent of the bubble.

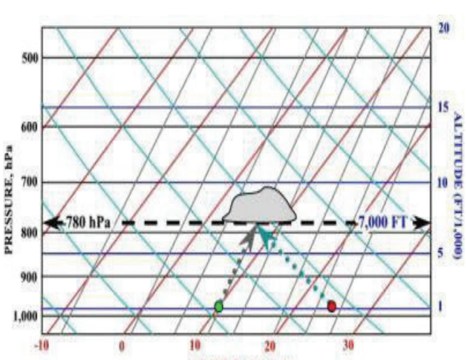


To predict whether clouds will form we need to know how the dewpoint of the bubble changes during its ascent. Lines of constant mixing ratio tell us. The “mixing ratio” is the concentration of water vapor in the air, expressed in grams of water per kilogram of air. Since this is a mass ratio (as opposed to a volume ratio), it does not change as the bubble expands. However, the dewpoint does change. A surface bubble with a dewpoint of about 10ºC has a dewpoint of about 2ºC at 18,000 feet.

To re-iterate: Lines of constant mixing ratio tell us how the dewpoint of a bubble changes with altitude. The mixing ratio line passing through the surface dewpoint tells us what the dewpoint of the lifted surface parcel is at any height. Since the temperature of rising air falls faster than does the dewpoint, unchecked ascent always results in cloud formation.

The origin of the decrease in dewpoint as a parcel ascends and cools is the associated expansion as the pressure drops. This expansion causes cooling, as we saw when considering the dry adiabats, but it also increases the average distance between water vapor molecules. Since condensation ipso facto involves an agglomeration of molecules, it is to be expected that having fewer molecules in a given volume will result in a lower dewpoint - i.e. the air will have to be colder to force condensation to occur.

Making Cumulus Clouds



We are now in a position to understand how the Skew-T handles clouds. Suppose we start with a surface parcel of air having a temperature of 25ºC and a dewpoint of 10ºC as depicted here. If the bubble is lifted from the surface to 7,000 ft its temperature drops to about 8ºC, and its dewpoint will drop to the same temperature: Since the dewpoint and temperature become equal at 7,000 feet condensation must occur, and a cloud forms.

The widely used formula for cloudbase is a consequence of the differing rates of change of the temperature and dewpoint of a lifted parcel of air.

DRY TEMPERATURE LAPSE RATE = 5.3 °F / 1,000 FT. (approximately) 2.5°C/1000ft

DEWPOINT LAPSE RATE = 0.9 °F / 1,000 FT (approximately) .5°C/1000ft

CLOUDBASE = ((T - DP) / 4.4) * 1,000 FT((Temp°C - DP°C)/2*1000ft

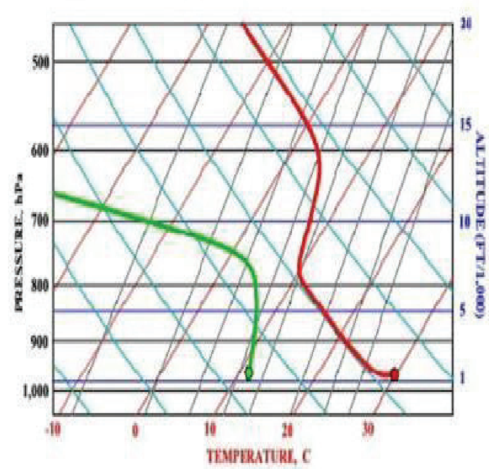
It is comforting to see that our first use of the Skew-T diagram predicts a familiar result. Our use of this feature of the chart occasionally fails since cumulus clouds never appear, especially if the air above the surface is significantly drier. The reason for this will soon become clear, as will the folly of relying too heavily on blind application.

Lapse Rates

The Skew-T diagram does double duty: It depicts by displaying lines - the calculations of the change in the temperature and dewpoint of a rising bubble in the absence of condensation, and the change in the temperature of a rising bubble where condensation is occurring - and it presents observed data. Perhaps it is this dual role which gives rise to some of the confusion which Skew- T's occasion. Further confusion arises because the term "lapse rate" also does double duty.

There are four lapse rates with which we will be dealing: The dry adiabatic, the saturated adiabatic, the temperature, and the dewpoint. Since the term "lapse rate" tends to get used imprecisely, this will make the distinction clear: The first two, the dry and saturated adiabatic lapse rates are calculated (using the adiabatic approximation) and that is why both always appear unchanged on every Skew-T plot. The second two, the temperature and dewpoint lapse rate are measured (or in the case of numerical model soundings, predicted values at the valid time of the forecast).

In the next illustration I have superimposed data lines upon the calculating lines, and it will now become apparent why the Skew-T diagram is so useful. The solid red line is the temperature of the air at the designated altitude. It's important to appreciate that every point on this line represents the actual or forecast temperature of the air at a given height.



From this plot, there are three regions of interest, three different lapse rates, in the red line: Close to the surface, the temperature decreases rather rapidly with increasing height. Then, from about a few hundred feet above the ground to about 6,000 feet, the temperature decreases at the DALR. From 6,000 ft the temperature decreases much more slowly. We need to understand why each region is the way it is, and what this implies for thermal forecasting.

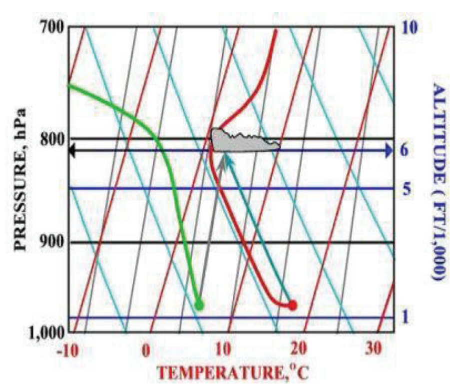
The lowest layer in this case, referred to as the "super adiabatic layer" exists courtesy of the sun. Its existence is of kinetic, not thermodynamic origin. As soon as the forcing insolation (heating) is cut off, it decays because any vertical displacement will result in the air finding itself in colder air. It is "unstable" in exactly the same sense that a rock on the edge of a cliff is unstable - a small push and it's gone. In the East super adiabatic layers are generally thin, akin to pushing off a small, shallow hill. In the West, this layer can grow to many hundreds of feet under sufficient sunshine, the equivalent of rolling the rock off the cliff. This is origin of dust devils which break loose with great energy, and rise to 15,000 feet or more.

From a few hundred feet above the surface to about 6,000 ft the temperature tracks the DALR - this is no accident: This depicts the area thermals will form. As the ground heats, and thermals mix up the air, so that its actual lapse rate inevitably becomes approximately dry adiabatic as long as the sun is shining.

Inversions
The next layer is generally referred to as an inversion. "Inversion" means the temperature remains the same, or increases with altitude. In this example, as is often the case, the temperature continues to drop with increasing height, so strictly speaking there is no inversion, however, the air above 6,000 feet is getting colder with increasing height a lot more slowly. On a blue day, it is the lowest lying inversion which caps the lift, and although this seems to place inversions in a poor light, their absence can cause problems, as I will show later on.

Dewpoint / Dewpoint Spread
The depicted solid green line is the dewpoint. If at any point the plotted dewpoint data touches, or is very close to the actual temperature plot – a cloud layer will form. If the dewpoint diverges away from the temperature plot, this indicates the air is drier. In this case, the shape is typical of a thermal soaring day, particularly in the tendency for the dewpoint and temperature to converge in the vicinity of the inversion and this too is no coincidence and has consequences discussed later.

Can We Soar?



We might as well start with a good day, so here's one I made up. It's typical of a good spring day in the East. The red line is what the model predicts the temperature lapse will be. The red dot is what the model predicts the average surface temperature will be. The cyan arrow follows the surface adiabat and because it is displaced from the temperature by about 2.5 C° to over 6,000 ft. this is a pretty unstable day. The greater the displacement, the greater the instability, the stronger the lift.

The green line and green dot are what the model predicts the dewpoint lapse rate will be. I have constructed the constant mixing ratio line passing through this value. That line
intersects the surface adiabat below the inversion, telling me that on this day lift will be marked by cumulus cloud. Note - at cloudbase, the air is still forecast to be 2.5 C° warmer than its surroundings, so on this day I would not expect lift to decrease with increasing height, as sometimes happens.

The dewpoint is well behaved, so I would not anticipate cumulus spread-out, and the inversion is more than enough to cap cloud growth, so overdevelopment is not predicted. I will discuss these two critical elements of the soaring forecast later.

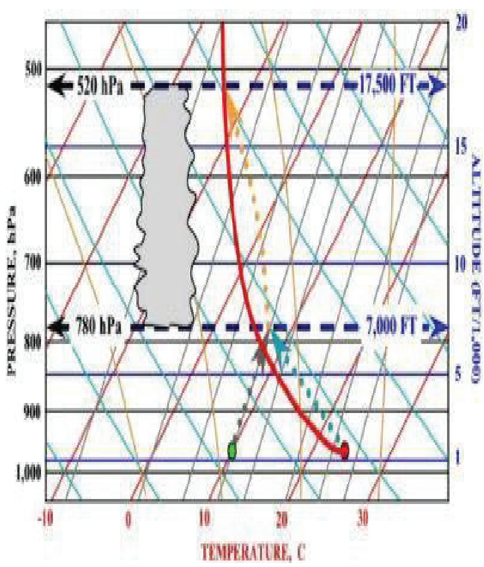
I am going to repeat much of what I said about the good day with cu, since I want to be sure everyone gets the picture, so here is what a good day without cu looks like. The red line is what

the model predicts the temperature lapse rate will be. The red dot is what the model predicts the average surface temperature will be.

The cyan arrow is the surface adiabat and is displaced from the temperature by about 2.5C to over 6,000 ft. so it's a pretty unstable day.

The green line and green dot are what the model predicts the dewpoint will be. I have constructed the constant mixing ratio line passing through this value. That line intersects the surface adiabat above the inversion, telling me that on this day lift will not be marked by cumulus cloud, and as a result, lift will be capped by the inversion.

What Goes on Above Cloud base?



When condensation occurs, the Saturated Adiabatic Lapse Rate (SALR) comes into play. Condensation releases heat - in the case of water vapor condensing to liquid water, large quantities of heat (7.5 Times than to evaporate at 440 cal./gram/C). Enough heat to drive convective storms and hurricanes.

We now add (orange) saturated adiabats. Observe that these lines and the dry adiabats (cyan) have a dramatically different slope at lower altitudes where the atmosphere is able to hold more water than it can at higher levels. Above about 500 hPa the saturated adiabats have the almost the same slope as the dry adiabats.

Air undergoing condensation as it ascends cools more slowly than does non-condensing air because of the release of latent heat from the vapor/liquid phase transformation.

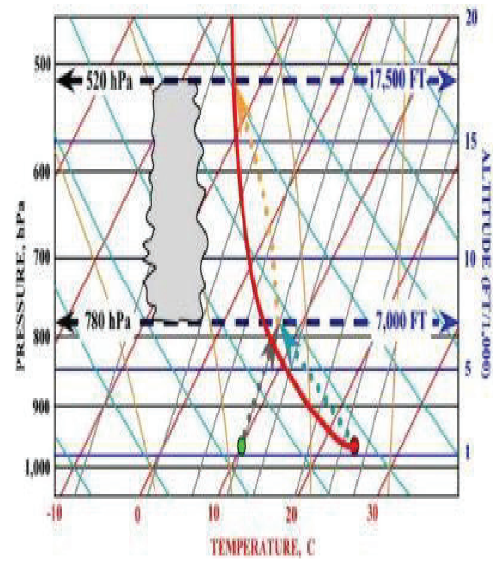
From this example, the area of the figure below 780 hPa should by now to look pretty familiar: Unstable surface air at about 24°C ascends until, at 7,000 ft its temperature and dewpoint are the same, at which point condensation occurs. So far so good, after all we want cu don't we?

The problem here is that there is no inversion in the vicinity of cloud base. As soon as clouds form, the dotted orange adiabat SALR takes over and the cloud will grow to about 17,500 ft. If a cloud grows to above the freezing level (which this one easily does - the temperature lapse rate crosses the 0 degree dry adiabat at 700 hPa) rain can form.

Not obvious from my illustration is that when convection extends to heights where winds are much stronger, those winds can mix down to the surface. My figure was adapted from the forecast sounding for a contest day at Mifflin County a few years ago. Although it was a generally good day, we saw isolated heavy rain showers and a 60 mph gusts at the field. This is why, at least on days with cu, we need an slight inversion to prevent overdevelopment, or Nimbus development, or at worst Thunderstorms.

CU Spreadout ("Over Development")

Many good soaring days are ruined by overdevelopment, or as I prefer to call it, spreadout. The cause of spreadout is predicted on inspection of this Skew-T example:



In the vicinity of cloudbase the dewpoint and temperature of the general airmass (i.e. all of the air NOT in thermals) are rather close to one another. Humidity is thus high, and dispersal of clouds through evaporation is slow.

If a temperature difference of less than 3°C at, or in the vicinity of cloud base, there is a good possibility of spread out. The smaller the difference, the greater the chance. It may seem historically, that the dewpoint so frequently approaches the temperature at the inversion, but this is no accident: The moisture is transported there by convection, and prevented from rising by the inversion.

Winds

Usually on the right hand side of the Skew-T is a vertical bar graph depicting wind barbs which depict direction (magnetic) and speed (knots) at the various altitudes. Whether the observed data, or predicted/forecast data, they are most helpful to determine where to look for thermals in relation to the surface, when low, or near cloud base, when high.

Direction changes greater than or close to 90 degrees at any level will cause significant shearing of any thermals. Generally, a light wind of 5 knots will aid in the release of thermals from the surface tension, break bubbles into rising columns, and allow mixing and ground cooling that helps regular thermal generation, and often earlier than predicted triggering of thermals.

Significant speed increases can predict the same mixing effects. Wind speed more than 15-20K will begin to fragment and make thermals irregular and choppy. Occasionally, a wind shift of 90 degrees at cloud base, will make it possible to climb up the side of cumulus, sometimes even above the thermal lift band.

The Effect of Moisture on Buoyancy

Because air is never completely dry, and since humid air is less dense than dry air, addition of water vapor decreases the density. Buoyancy depends on the density difference between the thermal that transports this parcel of air and the overlying airmass, we must account for the effect of water vapor. Another way of stating this is – Dry Air will have more momentum once it is motivated to move than more Humid Air. More Humid Air will cool at a slower rate when lifted, yet requires more energy to start the lifting process.

The effect is significant. It is accounted for by calculating the temperature the air would be at if it were dry, and of the same density. That temperature is known as the virtual temperature. On a typical East Coast soaring day the virtual temperature at the surface is about 2°C degrees higher than the 2 meter surface temperature used for observations.

The formula for calculating virtual temperature (Tv) is:

$$T_v = T + W/6 \text{ (approximately)}$$

Where T is the surface temperature in degrees C and W is the mixing ratio in grams of water/kg of air.

Incidentally, what is displayed on every government Skew-T diagram that I am familiar with is the uncorrected temperature, not virtual temperature so I generally make the assumption (not completely true) that a correction in the surface temperature can be made. This mostly effects the predicted height of clouds, which will actually be higher.

Cirrus and Other Clouds

General weather forecasts will usually include terms such as “partly” or “mostly” cloudy but they never say what kind of cloud. TAF and MOS (Model Output Statistics) forecasts are more helpful since they give the heights of cloud layers. Any Skew-T will make it clear the height and thickness of any cloud layer because the dewpoint and temperature lines will be close whenever cloud is likely.

Soaring Summary

The Skew-T diagram captures for a point on the surface the profile of the atmosphere above that point. It presents a complete picture of the temperature, the dewpoint and the wind speed and direction from the surface to about 80,000 ft. In addition to presenting a great deal of data in a highly compact form, the Skew-T also makes it simple to perform a variety of “what if?” calculations through the overlay of dry and wet adiabats, and lines of constant mixing ratio.

These diagrams are ideally suited to producing thermal soaring forecasts. With a little effort anyone interested in cross-country soaring (or even just staying up for that matter) can get a very good feel for the day with just a few minutes spent studying them. Even those pilots relying upon others for their forecasts would do well to look at the underlying data, and there is no better way to do that than the Skew-T.

For a video on how to read a skew-t go to : https://www.youtube.com/watch?v=STrCGN5TLoA

ROTOR! It is dangerous.

Flying ultralights is a four-dimensional game with the fourth dimension being the invisible air that we are harnessing to continue flying if we are not just sledding down in a nice still morning. When wind intersects an object, it forms a type of eddy behind that object which is full of turbulence. In Figure 3-1 you see wind hitting the top of a mountain and on the lee ward side of that wind just at and below mountain height is a very turbulent and dangerous zone called the Rotor (ville USA). Just as in fluid dynamics in a river the leeside of an obstacle where water hits has turbulent forces often pressing the canopy down and towards the ground. Often it is very difficult to control a glider in the rotor of an object. Rotor can come from tree lines, power lines, buildings, houses, and parked cars as well as many other objects that create this dangerous leeside condition that can cause severe turbulence that could be impossible to fly in.

Figure 3-1

Chapter 4 continued on next page...

This next section is taken directly from the Pilot Handbook of Aeronautical Knowledge created and distributed by the FAA. While some of the terminology is intended for fixed wing aircraft the meterology is important to every type of aviation. We have hand selected the most relevant topics but for entire copy please refer to https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/phak/

Structure of the Atmosphere

The atmosphere is an envelope of air that surrounds the Earth and rests upon its surface. It is as much a part of the Earth as is land and water. However, air differs from land and water in that it is a mixture of gases. It has mass, weight, and indefinite shape.

Air, like any other fluid, is able to flow and change its shape when subjected to even minute pressures because of the lack of strong molecular cohesion. For example, gas will completely fill any container into which it is placed, expanding or contracting to adjust its shape to the limits of the container.

The atmosphere is composed of 78% nitrogen, 21& oxygen, and 1% other gases, such as argon or helium. Most of the oxygen is contained below 35,000 feet altitude.

Atmospheric Pressure

Though there are various kinds of pressure, pilots are mainly concerned with atmospheric pressure. It is one of the basic factors in weather changes, helps to lift the aircraft, and actuates some of the most important flight instruments in the aircraft. These instruments often include the altimeter, the airspeed indicator (ASI), the vertical speed indicator (VSI), and the manifold pressure gauge. Though air is very light, it has mass and is affected by the attraction of gravity. Therefore, like any other substance, it has weight; because it has weight, it has force. Since it is a fluid substance, this force is exerted equally in all directions, and its effect on bodies within the air is called pressure. Under standard conditions at sea level, the average pressure exerted by the weight of the atmosphere is approximately 14.7 pounds per square inch (psi).

The density of air has significant effects on the aircraft's performance. As air becomes less dense, it reduces:

Power, because the engine takes in less air
Thrust, because the propeller is less efficient in thin air
Lift, because the thin air exerts less force on the airfoils

The pressure of the atmosphere may vary with time but more importantly, it varies with altitude and temperature. Due to the changing atmospheric pressure, a standard reference was developed. The standard atmosphere at sea level has a surface temperature of 59 degrees Fahrenheit (°F) or 15 degrees Celsius (°C) and a surface pressure of 29.92 inches of mercury ("Hg) or 1013.2 millibars (mb). *[Figure 11-1]*

A standard temperature lapse rate is one in which the temperature decreases at the rate of approximately 3.5 °F or 2 °C per thousand feet up to 36,000 feet. Above this point, the temperature is considered constant up to 80,000 feet. A standard pressure lapse rate is one in which pressure decreases at a rate of approximately 1 "Hg per 1,000 feet of altitude gain to 10,000 feet. [Figure 11-2] The International Civil Aviation Organization (ICAO) has established this as a worldwide standard, and it is often referred to as International Standard Atmosphere (ISA) or ICAO Standard Atmosphere. Any temperature or pressure that differs from the standard lapse rates is considered nonstandard temperature and pressure. Adjustments for nonstandard temperatures and pressures are provided on the manufacturer's performance charts.

Since all aircraft performance is compared and evaluated using the standard atmosphere, all aircraft instruments are calibrated for the standard atmosphere. Thus, certain corrections must apply to the instrumentation, as well as the aircraft performance, if the actual operating conditions do not fit the standard atmosphere. In order to account properly for the nonstandard atmosphere, certain related terms must be defined.

Pressure Altitude

Pressure altitude is the height above the standard datum plane (SDP). The aircraft altimeter is essentially a sensitive barometer calibrated to indicate altitude in the standard atmosphere. If the altimeter is set for 29.92 "Hg SDP, the altitude indicated is the pressure altitude—the altitude in the standard atmosphere corresponding to the sensed pressure.

The SDP is a theoretical level at which the pressure of the atmosphere is 29.92 "Hg and the weight of air is 14.7 psi. As atmospheric pressure changes, the SDP may be below, at, or above sea level. Pressure altitude is important as a basis for determining aircraft performance, as well as for assigning flight levels to aircraft operating at above 18,000 feet.

Density Altitude

The more appropriate term for correlating aerodynamic performance in the nonstandard atmosphere is density altitude—the altitude in the standard atmosphere corresponding to a particular value of air density. Density altitude is pressure altitude corrected for nonstandard temperature. As the density of the air increases (lower density altitude), aircraft performance increases. Conversely, as air density decreases (higher density altitude), aircraft performance decreases. A decrease in air density means a high-density altitude; an increase in air density means a lower density altitude. Density altitude is used in calculating aircraft performance. Under standard atmospheric condition, air at each level in the atmosphere has a specific density; under standard conditions, pressure altitude and density altitude identify the same level. Density altitude, then, is the vertical distance above sea level in the standard atmosphere at which a given density is to be found.

Density altitude is computed using pressure altitude and temperature. Since aircraft performance data at any level is based upon air density under standard day conditions, such performance data apply to air density levels that may not be identical to altimeter indications. Under conditions higher or lower than standard, these levels cannot be determined directly from the altimeter.

Density altitude is determined by first finding pressure altitude and then correcting this altitude for nonstandard temperature variations. Since density varies directly with pressure, and inversely with temperature, a given pressure altitude may exist for a wide range of temperature by allowing the density to vary. However, a known density occurs for any one temperature and pressure altitude. The density of the air, of course, has a pronounced effect on aircraft and engine performance. Regardless of the actual altitude at which the aircraft is operating, it will perform as though it were operating at an altitude equal to the existing density altitude.

For example, when set at 29.92 “Hg, the altimeter may indicate a pressure altitude of 5,000 feet. According to the AFM/POH, the ground run on takeoff may require a distance of 790 feet under standard temperature conditions. However, if the temperature is 20 °C above standard, the expansion of air raises the density level. Using temperature correction data from tables or graphs, or by deriving the density altitude with a computer, it may be found that the density level is above 7,000 feet, and the ground run may be closer to 1,000 feet.

Air density is affected by changes in altitude, temperature, and humidity. High density altitude refers to thin air while low density altitude refers to dense air. The conditions that result in a high density altitude are high elevations, low atmospheric pressures, high temperatures, high humidity, or some combination of these factors. Lower elevations, high atmospheric pressure, low temperatures, and low humidity are more indicative of low density altitude.

Effects of Temperature on Density

Increasing the temperature of a substance decreases its density. Conversely, decreasing the temperature increases the density. Thus, the density of air varies inversely with temperature. This statement is true only at a constant pressure.

In the atmosphere, both temperature and pressure decrease with altitude and have conflicting effects upon density. However, the fairly rapid drop in pressure as altitude is increased usually has the dominant effect. Hence, pilots can expect the density to decrease with altitude.

Effects of Humidity (Moisture) on Density

The preceding paragraphs are based on the presupposition of perfectly dry air. In reality, it is never completely dry. The small amount of water vapor suspended in the atmosphere may be negligible under certain conditions, but in other conditions humidity may become an important factor in the performance of an aircraft. Water vapor is lighter than air; consequently, moist air is lighter than dry air. Therefore, as the water content of the air increases, the air becomes less dense, increasing density altitude and decreasing performance. It is lightest or least dense when, in a given set of conditions, it contains the maximum amount of water vapor.

Humidity, also called relative humidity, refers to the amount of water vapor contained in the atmosphere and is expressed as a percentage of the maximum amount of water vapor the air can hold. This amount varies with the temperature; warm air can hold more water vapor, while colder air can hold less. Perfectly dry air that contains no water vapor has a relative humidity of zero percent, while saturated air that cannot hold any more water vapor has a relative humidity of 100 percent. Humidity alone is usually not considered an essential factor in calculating density altitude and aircraft performance; however, it does contribute.

The higher the temperature, the greater amount of water vapor that the air can hold. When comparing two separate air masses, the first warm and moist (both qualities making air lighter) and the second cold and dry (both qualities making it heavier), the first must be less dense than the second. Pressure, temperature, and humidity have a great influence on aircraft performance because of their effect upon density. There is no rule-of-thumb or chart used to compute the effects of humidity on density altitude, but it must be taken into consideration. Expect a decrease in overall performance in high humidity conditions.

Performance

Performance is a term used to describe the ability of an aircraft to accomplish certain things that make it useful for certain purposes. For example, the ability of an aircraft to land and take off in a very short distance is an important factor to the pilot who operates in and out of short, unimproved airfields. The ability to carry heavy loads, fly at high altitudes at fast speeds, and/or travel long distances is essential for the performance of airline and executive type aircraft.

The primary factors most affected by performance are the takeoff and landing distance, rate of climb, ceiling, payload, range, speed, maneuverability, stability, and fuel economy. Some of these factors are often directly opposed: for example, high speed versus short landing distance, long range versus great payload, and high rate of climb versus fuel economy. It is the preeminence of one or more of these factors that dictates differences between aircraft and explains the high degree of specialization found in modern aircraft.

The various items of aircraft performance result from the combination of aircraft and powerplant characteristics. The aerodynamic characteristics of the aircraft generally define the power and thrust requirements at various conditions of flight, while powerplant characteristics generally define the power and thrust available at various conditions of flight. The matching of the aerodynamic configuration with the powerplant is accomplished by the manufacturer to provide maximum performance at the specific design condition (e.g., range, endurance, and climb).

Straight-and-Level Flight

All of the principal components of flight performance involve steady-state flight conditions and equilibrium of the aircraft. For the aircraft to remain in steady, level flight, equilibrium must be obtained by a lift equal to the aircraft weight and a powerplant thrust equal to the aircraft drag. Thus, the aircraft drag defines the thrust required to maintain steady, level flight. As presented in Chapter 4, Aerodynamics of Flight, all parts of an aircraft contribute to the drag, either induced (from lifting surfaces) or parasite drag.

While parasite drag predominates at high speed, induced drag predominates at low speed. [Figure 4-2] For example, if an aircraft in a steady flight condition at 100 knots is then accelerated to 200 knots, the parasite drag becomes four times as great, but the power required to overcome that drag is eight times

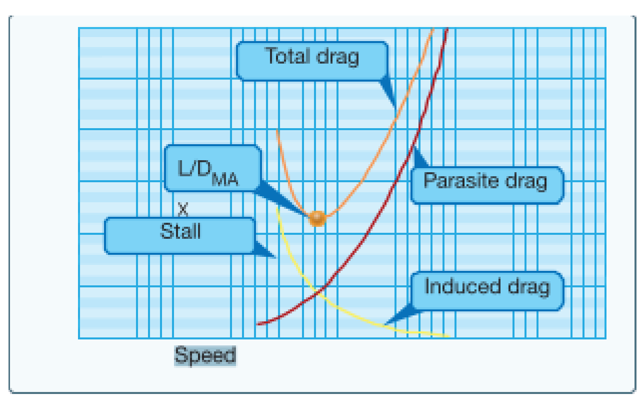


Figure 4-2

the original value. Conversely, when the aircraft is steady, level flight at twice as great a speed, the induced drag is one-fourth the original value, and the power required to overcome that drag is only one-half the original value.

Wind and Pressure Representation Surface Weather Maps

Surface weather maps provide information about fronts, areas of high and low pressure, and surface winds and pressures for each station. This type of weather map allows pilots to see the locations of fronts and pressure systems, but more importantly, it depicts the wind and pressure at the surface for each location.

Wind conditions are reported by an arrow attached to the station location circle. [Figure 4-3] The station circle represents the head of the arrow, with the arrow pointing in the direction from which the wind is blowing. Winds are described by the direction from which they blow, thus a northwest wind means that the wind is blowing from the northwest toward the southeast. The speed of the wind is depicted by barbs or pennants placed on the wind line. Each barb represents a speed of ten knots, while half a barb is equal to five knots, and a pennant is equal to 50 knots.

The pressure for each station is recorded on the weather chart and is shown in mb. Isobars are lines drawn on the chart to depict lines of equal pressure. These lines result in a pattern that reveals the pressure gradient or change in pressure over distance. Isobars are similar to contour lines on a topographic map that indicate terrain altitudes and slope steepness. For example, isobars that are closely spaced indicate a steep pressure gradient and strong winds prevail. Shallow gradients, on the other hand, are represented by isobars that are spaced far apart and are indicative of light winds. Isobars help identify low- and high-pressure systems, as well as the location of ridges and troughs. A high is an area of high pressure surrounded by lower pressure; a low is an area of low pressure surrounded by higher pressure. A ridge is an elongated area of high pressure, and a trough is an elongated area of low pressure. Isobars furnish valuable information about winds in the first few thousand feet above the surface. Close to the ground, wind direction is modified by the friction and wind speed decreases due to friction with the surface. At levels 2,000 to 3,000 feet above the surface, however, the speed is greater and the direction becomes more parallel to the isobars.

Generally, the wind 2,000 feet above ground level (AGL) is 20° to 40° to the right of surface winds, and the wind speed is greater. The change of wind direction is greatest over rough terrain and least over flat surfaces, such as open water. In the absence of winds aloft information, this rule of thumb allows for a rough estimate of the wind conditions a few thousand feet above the surface.

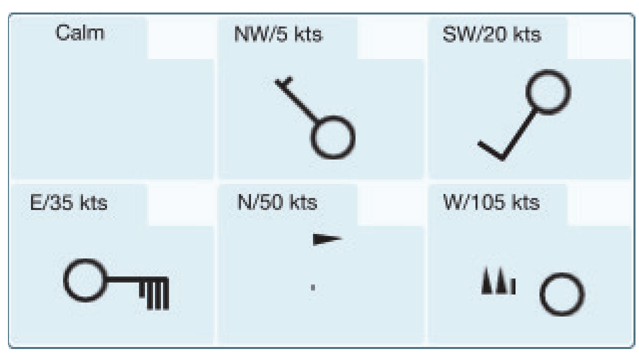


Figure 4-3

Atmospheric Stability

The stability of the atmosphere depends on its ability to resist vertical motion. A stable atmosphere makes vertical movement difficult, and small vertical disturbances dampen out and disappear. In an unstable atmosphere, small vertical air movements tend to become larger, resulting in turbulent airflow and convective activity. Instability can lead to significant turbulence, extensive vertical clouds, and severe weather.

Rising air expands and cools due to the decrease in air pressure as altitude increases. The opposite is true of descending air; as atmospheric pressure increases, the temperature of descending air increases as it is compressed. Adiabatic heating and adiabatic cooling are terms used to describe this temperature change. The adiabatic process takes place in all upward and downward moving air. When air rises into an area of lower pressure, it expands to a larger volume. As the molecules of air expand, the temperature of the air lowers. As a result, when a parcel of air rises, pressure decreases, volume increases, and temperature decreases. When air descends, the opposite is true. The rate at which temperature decreases with an increase in altitude is referred to as its lapse rate. As air ascends through the atmosphere, the average rate of temperature change is 2 °C (3.5 °F) per 1,000 feet.

Since water vapor is lighter than air, moisture decreases air density, causing it to rise. Conversely, as moisture decreases, air becomes denser and tends to sink. Since moist air cools at a slower rate, it is generally less stable than dry air since the moist air must rise higher before its temperature cools to that of the surrounding air. The dry adiabatic lapse rate (unsaturated air) is 3 °C (5.4 °F) per 1,000 feet. The moist adiabatic lapse rate varies from 1.1 °C to 2.8 °C (2 °F to 5 °F) per 1,000 feet.

The combination of moisture and temperature determine the stability of the air and the resulting weather. Cool, dry air is very stable and resists vertical movement, which leads to good and generally clear weather. The greatest instability occurs when the air is moist and warm, as it is in the tropical regions in the summer. Typically, thunderstorms appear on a daily basis in these regions due to the instability of the surrounding air.

Inversion

As air rises and expands in the atmosphere, the temperature decreases. There is an atmospheric anomaly that can occur; however, that changes this typical pattern of atmospheric behavior. When the temperature of the air rises with altitude, a temperature inversion exists. Inversion layers are commonly shallow layers of smooth, stable air close to the ground. The temperature of the air increases with altitude to a certain point, which is the top of the inversion. The air at the top of the layer acts as a lid, keeping weather and pollutants trapped below. If the relative humidity of the air is high, it can contribute to the formation of clouds, fog, haze, or smoke resulting in diminished visibility in the inversion layer.

Surface-based temperature inversions occur on clear, cool nights when the air close to the ground is cooled by the lowering temperature of the ground. The air within a few hundred feet of the surface becomes cooler than the air above it. Frontal inversions occur when warm air spreads over a layer of cooler air, or cooler air is forced under a layer of warmer air.

Moisture and Temperature

The atmosphere, by nature, contains moisture in the form of water vapor. The amount of moisture present in the atmosphere is dependent upon the temperature of the air. Every 20 °F increase in temperature doubles the amount of moisture the air can hold. Conversely, a decrease of 20 °F cuts the capacity in half.

Water is present in the atmosphere in three states: liquid, solid, and gaseous. All three forms can readily change to another, and all are present within the temperature ranges of the atmosphere. As water changes from one state to another, an exchange of heat takes place. These changes occur through the processes of evaporation, sublimation, condensation, deposition, melting, or freezing. However, water vapor is added into the atmosphere only by the processes of evaporation and sublimation.

Evaporation is the changing of liquid water to water vapor. As water vapor forms, it absorbs heat from the nearest available source. This heat exchange is known as the latent heat of evaporation. A good example is the evaporation of human perspiration. The net effect is a cooling sensation as heat is extracted from the body. Similarly, sublimation is the changing of ice directly to water vapor, completely bypassing the liquid stage. Though dry ice is not made of water, but rather carbon dioxide, it demonstrates the principle of sublimation when a solid turns directly into vapor.

Relative Humidity

Humidity refers to the amount of water vapor present in the atmosphere at a given time. Relative humidity is the actual amount of moisture in the air compared to the total amount of moisture the air could hold at that temperature. For example, if the current relative humidity is 65 percent, the air is holding 65 percent of the total amount of moisture that it can hold at that temperature and pressure. While much of the western United States rarely sees days of high humidity, relative humidity readings of 75 to 90 percent are not uncommon in the southern United States during warmer months. *[Figure 4-4]*

Temperature/Dew Point Relationship

The relationship between dew point and temperature defines the concept of relative humidity. The dew point, given in degrees, is the temperature at which the air can hold no more moisture. When the temperature of the air is reduced to the dew point, the air is completely saturated, and moisture begins to condense out of the air in the form of fog, dew, frost, clouds, rain, or snow.

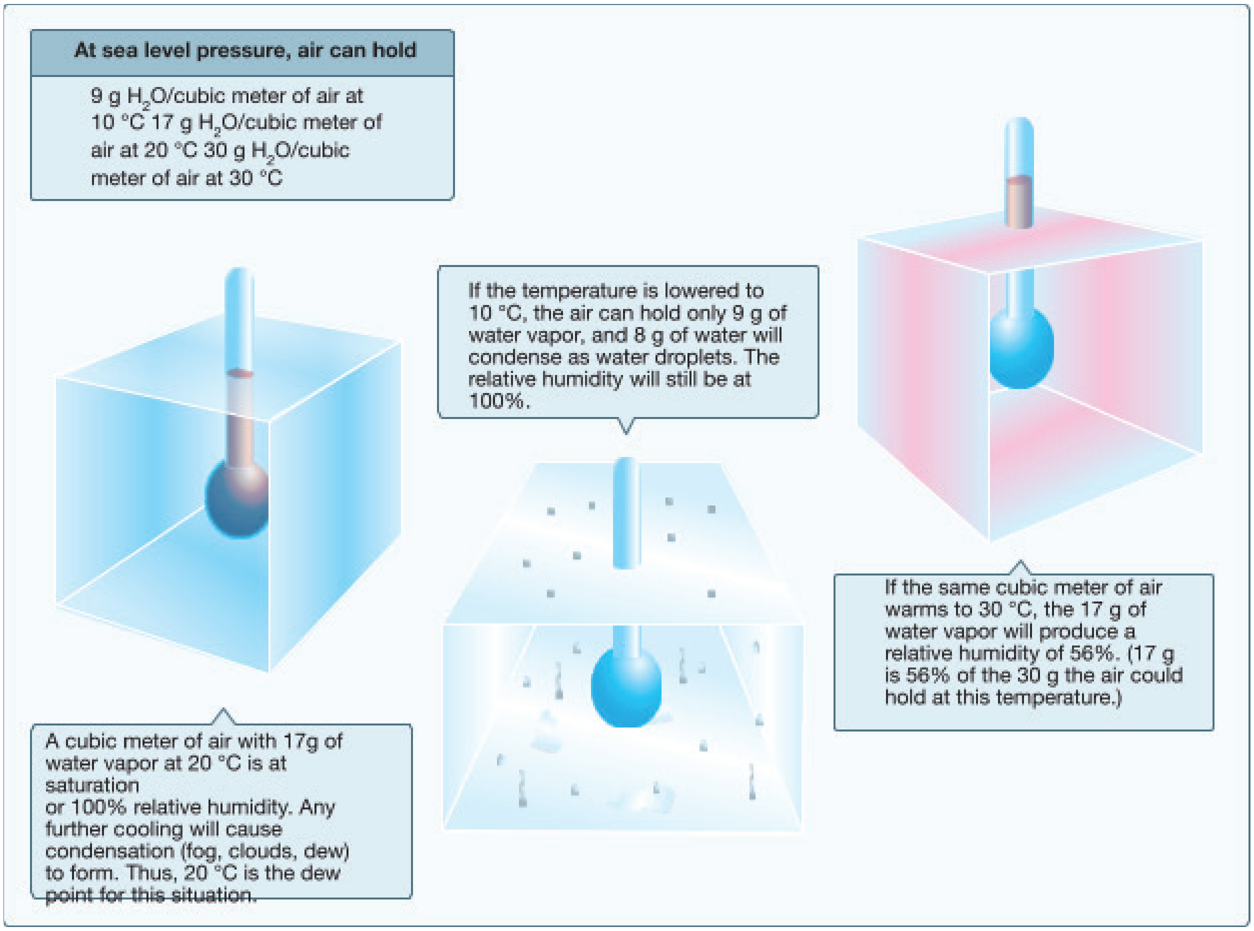


Figure 4-4

Methods by Which Air Reaches the Saturation Point

If air reaches the saturation point while temperature and dew point are close together, it is highly likely that fog, low clouds, and precipitation will form. There are four methods by which air can reach the saturation point. First, when warm air moves over a cold surface, the air temperature drops and reaches the saturation point. Second, the saturation point may be reached when cold air and warm air mix. Third, when air cools at night through contact with the cooler ground, air reaches its saturation point. The fourth method occurs when air is lifted or is forced upward in the atmosphere.

As air rises, it uses heat energy to expand. As a result, the rising air loses heat rapidly. Unsaturated air loses heat at a rate of 3.0°C (5.4 °F) for every 1,000 feet of altitude gain. No matter what causes the air to reach its saturation point, saturated air brings clouds, rain, and other critical weather situations.

Clouds

Clouds are visible indicators and are often indicative of future weather. For clouds to form, there must be adequate water vapor and condensation nuclei, as well as a method by which the air can be cooled. When the air cools and reaches its saturation point, the invisible water vapor changes into a visible state. Through the processes of deposition (also referred to as sublimation) and condensation, moisture condenses or sublimates onto miniscule particles of matter like dust, salt, and smoke known as condensation nuclei. The nuclei are important because they provide a means for the moisture to change from one state to another.

Cloud type is determined by its height, shape, and characteristics. They are classified according to the height of their bases as low, middle, or high clouds, as well as clouds with vertical development. *[Figure 4-5]*

Low clouds are those that form near the Earth's surface and extend up to about 6,500 feet AGL. They are made primarily of water droplets but can include supercooled water droplets that induce hazardous aircraft icing. Typical low clouds are stratus, stratocumulus, and nimbostratus. Fog is also classified as a type of low cloud formation. Clouds in this family create low ceilings, hamper visibility, and can change rapidly. Because of this, they influence flight planning and can make visual flight rules (VFR) flight impossible.

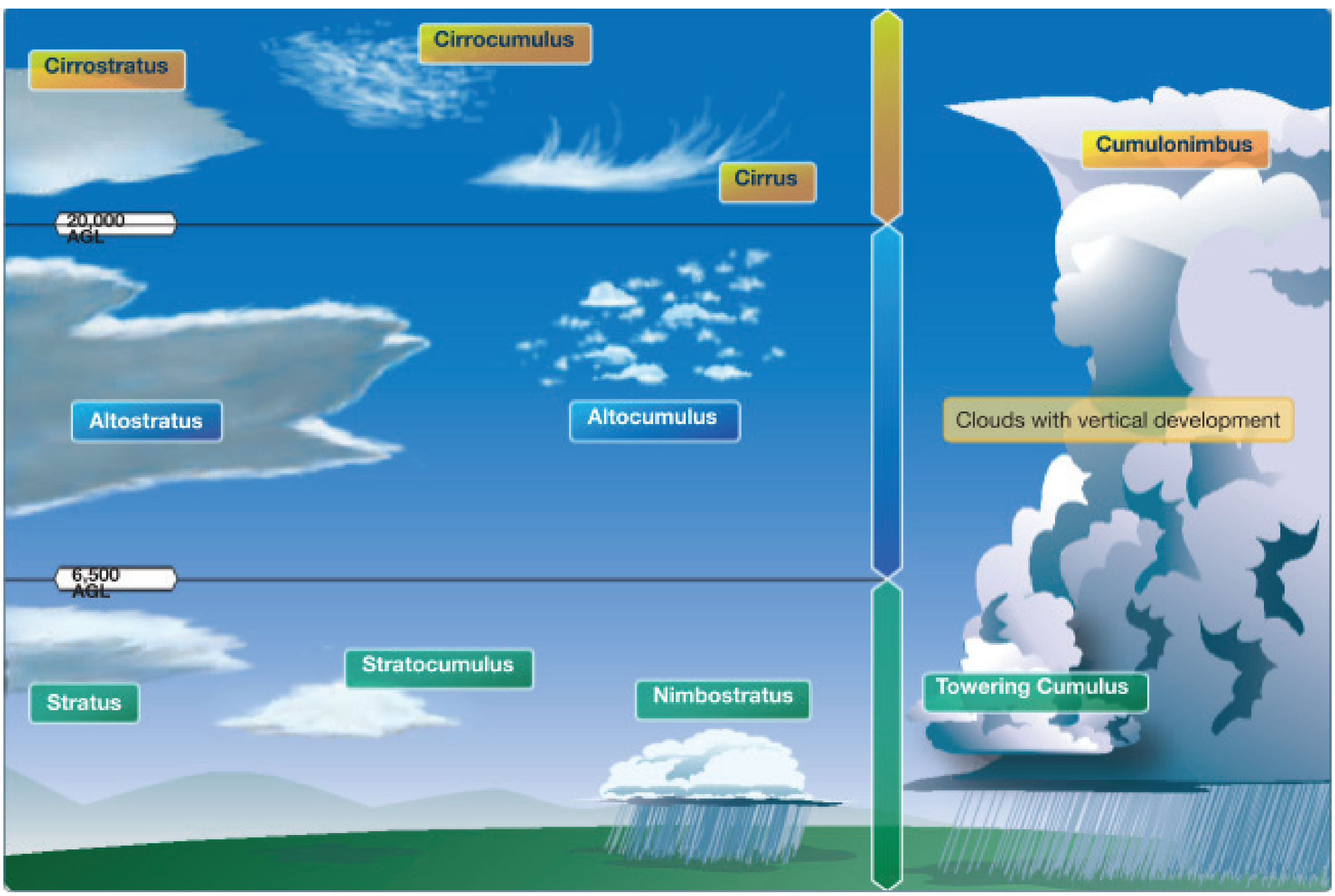


Figure 4-5

Middle clouds form around 6,500 feet AGL and extend up to 20,000 feet AGL. They are composed of water, ice crystals, and supercooled water droplets. Typical middle-level clouds include altostratus and altocumulus. These types of clouds may be encountered on cross-country flights at higher altitudes. Altostratus clouds can produce turbulence and may contain moderate icing. Altocumulus clouds, which usually form when altostratus clouds are breaking apart, also may contain light turbulence and icing.

High clouds form above 20,000 feet AGL and usually form only in stable air. They are made up of ice crystals and pose no real threat of turbulence or aircraft icing. Typical high level clouds are cirrus, cirrostratus, and cirrocumulus.

Clouds with extensive vertical development are cumulus clouds that build vertically into towering cumulus or cumulonimbus clouds. The bases of these clouds form in the low to middle cloud base region but can extend into high altitude cloud levels. Towering cumulus clouds indicate areas of instability in the atmosphere, and the air around and inside them is turbulent. These types of clouds often develop into cumulonimbus clouds or thunderstorms. Cumulonimbus clouds contain large amounts of moisture and unstable air and usually produce hazardous weather phenomena, such as lightning, hail, tornadoes, gusty winds, and wind shear. These extensive vertical clouds can be obscured by other cloud formations and are not always visible from the ground or while in flight. When this happens, these clouds are said to be embedded, hence the term, embedded thunderstorms.

To pilots, the cumulonimbus cloud is perhaps the most dangerous cloud type. It appears individually or in groups and is known as either an air mass or orographic thunderstorm. Heating of the air near the Earth's surface creates an air mass thunderstorm; the upslope motion of air in the mountainous regions causes orographic thunderstorms. Cumulonimbus clouds that form in a continuous line are nonfrontal bands of thunderstorms or squall lines.

Since rising air currents cause cumulonimbus clouds, they are extremely turbulent and pose a significant hazard to flight safety. For example, if an aircraft enters a thunderstorm, the aircraft could experience updrafts and downdrafts that exceed 3,000 fpm. In addition, thunderstorms can produce large hailstones, damaging lightning, tornadoes, and large quantities of water, all of which are potentially hazardous to aircraft. Cloud classification can be further broken down into specific cloud types according to the outward appearance and cloud composition. Knowing these terms can help a pilot identify visible clouds.

The following is a list of cloud classifications:

Cumulus—heaped or piled clouds
Stratus—formed in layers
Cirrus—ringlets, fibrous clouds, also high level clouds above 20,000 feet
Castellanus—common base with separate vertical development, castle-like
Lenticularus—lens-shaped, formed over mountains in strong winds
Nimbus—rain-bearing clouds
Fracto—ragged or broken
Alto—middle level clouds existing at 5,000 to 20,000 feet

Ceiling

For aviation purposes, a ceiling is the lowest layer of clouds reported as being broken or overcast, or the vertical visibility into an obscuration like fog or haze. Clouds are reported as broken when five-eighths to seven-eighths of the sky is covered with clouds. Overcast means the entire sky is covered with clouds. Current ceiling information is reported by the aviation routine weather report (METAR) and automated weather stations of various types.

Visibility

Closely related to cloud cover and reported ceilings is visibility information. Visibility refers to the greatest horizontal distance at which prominent objects can be viewed with the naked eye. Current visibility is also reported in METAR and other aviation weather reports, as well as by automated weather systems. Visibility information, as predicted by meteorologists, is available for a pilot during a preflight weather briefing.

Precipitation

Precipitation refers to any type of water particles that form in the atmosphere and fall to the ground. It has a profound impact on flight safety. Depending on the form of precipitation, it can reduce visibility, create icing situations, and affect landing and takeoff performance of an aircraft.

Precipitation occurs because water or ice particles in clouds grow in size until the atmosphere can no longer support them. It can occur in several forms as it falls toward the Earth, including drizzle, rain, ice pellets, hail, snow, and ice.

Drizzle is classified as very small water droplets, smaller than 0.02 inches in diameter. Drizzle usually accompanies fog or low stratus clouds. Water droplets of larger size are referred to as rain. Rain that falls through the atmosphere but evaporates prior to striking the ground is known as virga. Freezing rain and freezing drizzle occur when the temperature of the surface is below freezing; the rain freezes on contact with the cooler surface.

If rain falls through a temperature inversion, it may freeze as it passes through the underlying cold air and fall to the ground in the form of ice pellets. Ice pellets are an indication of a temperature inversion and that freezing rain exists at a higher altitude. In the case of hail, freezing water droplets are carried up and down by drafts inside cumulonimbus clouds, growing larger in size as they come in contact with more moisture. Once the updrafts can no longer hold the freezing water, it falls to the Earth in the form of hail. Hail can be pea sized, or it can grow as large as five inches in diameter, larger than a softball.

Snow is precipitation in the form of ice crystals that falls at a steady rate or in snow showers that begin, change in intensity, and end rapidly. Snow also varies in size, from very small grains to large flakes. Snow grains are the equivalent of drizzle in size.

Precipitation in any form poses a threat to safety of flight. Often, precipitation is accompanied by low ceilings and reduced visibility. Aircraft that have ice, snow, or frost on their surfaces must be carefully cleaned prior to beginning a flight because of the possible airflow disruption and loss of lift. Rain can contribute to water in the fuel tanks. Precipitation can create hazards on the runway surface itself, making takeoffs and landings difficult, if not impossible, due to snow, ice, or pooling water and very slick surfaces.

Air Masses

Air masses are classified according to the regions where they originate. They are large bodies of air that take on the characteristics of the surrounding area or source region. A source region is typically an area in which the air remains relatively stagnant for a period of days or longer. During this time of stagnation, the air mass takes on the temperature and moisture characteristics of the source region. Areas of stagnation can be found in polar regions, tropical oceans, and dry deserts. Air masses are generally identified as polar or tropical based on temperature characteristics and maritime or continental based on moisture content.

A continental polar air mass forms over a polar region and brings cool, dry air with it. Maritime tropical air masses form over warm tropical waters like the Caribbean Sea and bring warm, moist air. As the air mass moves from its source region and passes over land or water, the air mass is subjected to the varying conditions of the land or water which modify the nature of the air mass.

An air mass passing over a warmer surface is warmed from below, and convective currents form, causing the air to rise. This creates an unstable air mass with good surface visibility. Moist, unstable air causes cumulus clouds, showers, and turbulence to form.

Conversely, an air mass passing over a colder surface does not form convective currents but instead creates a stable air mass with poor surface visibility. The poor surface visibility is due to the fact that smoke, dust, and other particles cannot rise out of the air mass and are instead trapped near the surface. A stable air mass can produce low stratus clouds and fog.

Fronts

As an air mass moves across bodies of water and land, it eventually comes in contact with another air mass with different characteristics. The boundary layer between two types of air masses is known as a front. An approaching front of any type always means changes to the weather are imminent.

There are four types of fronts that are named according to the temperature of the advancing air relative to the temperature of the air it is replacing: *[Figure 4-6]*

- Warm
- Cold
- Stationary
- Occluded

Any discussion of frontal systems must be tempered with the knowledge that no two fronts are the same. However, generalized weather conditions are associated with a specific type of front that helps identify the front.

Warm Front

A warm front occurs when a warm mass of air advances and replaces a body of colder air. Warm fronts move slowly, typically 10 to 25 miles per hour (mph). The slope of the advancing front slides over the top of the cooler air and gradually pushes it out of the area. Warm fronts contain warm air that often has very high humidity. As the warm air is lifted, the temperature drops and condensation occurs.

Generally, prior to the passage of a warm front, cirriform or stratiform clouds, along with fog, can be expected to form along the frontal boundary. In the summer months, cumulonimbus clouds (thunderstorms) are likely to develop.

Light to moderate precipitation is probable, usually in the form of rain, sleet, snow, or drizzle, accentuated by poor visibility. The wind blows from the south-southeast, and the outside temperature is cool or cold with an increasing dew point. Finally, as the warm front approaches, the barometric pressure continues to fall until the front passes completely.

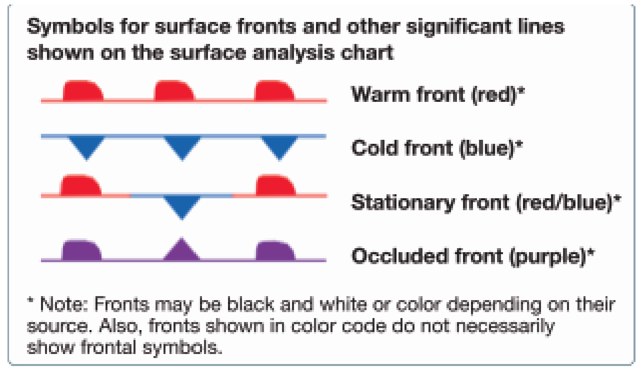


Figure 4-6. Common chart symbology to depict weather front location.

During the passage of a warm front, stratiform clouds are visible and drizzle may be falling. The visibility is generally poor, but improves with variable winds. The temperature rises steadily from the inflow of relatively warmer air. For the most part, the dew point remains steady and the pressure levels off. After the passage of a warm front, stratocumulus clouds predominate, and rain showers are possible. The visibility eventually improves, but hazy conditions may exist for a short period after passage. The wind blows from the south- southwest. With warming temperatures, the dew point rises and then levels off. There is generally a slight rise in barometric pressure, followed by a decrease of barometric pressure.

Cold Front

A cold front occurs when a mass of cold, dense, and stable air advances and replaces a body of warmer air.

Cold fronts move more rapidly than warm fronts, progressing at a rate of 25 to 30 mph. However, extreme cold fronts have been recorded moving at speeds of up to 60 mph. A typical cold front moves in a manner opposite that of a warm front. It is so dense, it stays close to the ground and acts like a snowplow, sliding under the warmer air and forcing the less dense air aloft. The rapidly ascending air causes the temperature to decrease suddenly, forcing the creation of clouds. The type of clouds that form depends on the stability of the warmer air mass. A cold front in the Northern Hemisphere is normally oriented in a northeast to southwest manner and can be several hundred miles long, encompassing a large area of land.

Prior to the passage of a typical cold front, cirriform or towering cumulus clouds are present, and cumulonimbus clouds may develop. Rain showers may also develop due to the rapid development of clouds. A high dew point and falling barometric pressure are indicative of imminent cold front passage.

As the cold front passes, towering cumulus or cumulonimbus clouds continue to dominate the sky. Depending on the intensity of the cold front, heavy rain showers form and may be accompanied by lightning, thunder, and/or hail. More severe cold fronts can also produce tornadoes. During cold front passage, the visibility is poor with winds variable and gusty, and the temperature and dew point drop rapidly. A quickly falling barometric pressure bottoms out during frontal passage, then begins a gradual increase.

After frontal passage, the towering cumulus and cumulonimbus clouds begin to dissipate to cumulus clouds with a corresponding decrease in the precipitation. Good visibility eventually prevails with the winds from the west- northwest. Temperatures remain cooler and the barometric pressure continues to rise.

Fast-Moving Cold Front

Fast-moving cold fronts are pushed by intense pressure systems far behind the actual front. The friction between the ground and the cold front retards the movement of the front and creates a steeper frontal surface. This results in a very narrow band of weather, concentrated along the leading edge of the front. If the warm air being overtaken by the cold front is relatively stable, overcast skies and rain may occur for some distance behind the front. If the warm air is unstable, scattered thunderstorms and rain showers may form. A continuous line of thunderstorms, or squall line, may form along or ahead of the front. Squall lines present a serious hazard to pilots as squall-type thunderstorms are intense and move quickly. Behind a fast-moving cold front, the skies usually clear rapidly, and the front leaves behind gusty, turbulent winds and colder temperatures.

Comparison of Cold and Warm Fronts

Warm fronts and cold fronts are very different in nature as are the hazards associated with each front. They vary in speed, composition, weather phenomenon, and prediction. Cold fronts, which move at 20 to 35 mph, travel faster than warm fronts, which move at only 10 to 25 mph. Cold fronts also possess a steeper frontal slope. Violent weather activity is associated with cold fronts, and the weather usually occurs along the frontal boundary, not in advance. However, squall lines can form during the summer months as far as 200 miles in advance of a strong cold front. Whereas warm fronts bring low ceilings, poor visibility, and rain, cold fronts bring sudden storms, gusty winds, turbulence, and sometimes hail or tornadoes.

Cold fronts are fast approaching with little or no warning, and they bring about a complete weather change in just a few hours. The weather clears rapidly after passage and drier air with unlimited visibilities prevail. Warm fronts, on the other hand, provide advance warning of their approach and can take days to pass through a region.

METAR	KSTL SCT010	1950Z3	0018KT 08/02	10SM A2979	
METAR	KIND OVC010	1950Z2	0024KT 24/23	3SM A2974	+TSRA
METAR	KCMH BKN025	1950Z2	0012KT 25/24	6SM A2983	HZ
METAR	KPIT SCT035	1950Z2	0012KT 24/22	3SM A2989	FU

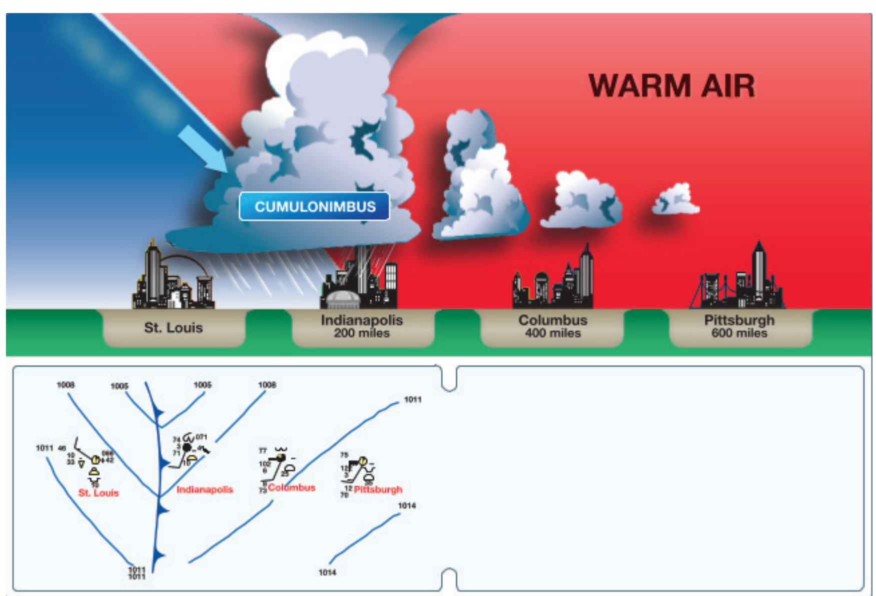


Figure 4-7. Cold front cross-section with surface weather chart depiction and associated METAR.

Wind Shifts

Wind around a high-pressure system rotates clockwise, while low-pressure winds rotate counter-clockwise. When two high pressure systems are adjacent, the winds are almost in direct opposition to each other at the point of contact. Fronts are the boundaries between two areas of high pressure, and therefore, wind shifts are continually occurring within a front. Shifting wind direction is most pronounced in conjunction with cold fronts.

Stationary Front

When the forces of two air masses are relatively equal, the boundary or front that separates them remains stationary and influences the local weather for days. This front is called a stationary front. The weather associated with a stationary front is typically a mixture that can be found in both warm and cold fronts.

Occluded Front

An occluded front occurs when a fast-moving cold front catches up with a slow-moving warm front. As the occluded front approaches, warm front weather prevails but is immediately followed by cold front weather. There are two types of occluded fronts that can occur, and the temperatures of the colliding frontal systems play a large part in defining the type of front and the resulting weather. A cold front occlusion occurs when a fast-moving cold front is colder than the air ahead of the slow moving warm front. When this occurs, the cold air replaces the cool air and forces the warm front aloft into the atmosphere. Typically, the cold front occlusion creates a mixture of weather found in both warm and cold fronts, providing the air is relatively stable. A warm front occlusion occurs when the air ahead of the warm front is colder than the air of the cold front. When this is the case, the cold front rides up and over the warm front. If the air forced aloft by the warm front occlusion is unstable, the weather is more severe than the weather found in a cold front occlusion. Embedded thunderstorms, rain, and fog are likely to occur.

Figure 4-7 depicts a cross-section of a typical cold front occlusion. The warm front slopes over the prevailing cooler air and produces the warm front type weather. Prior to the passage of the typical occluded front, cirriform and stratiform clouds prevail, light to heavy precipitation falls, visibility is poor, dew point is steady, and barometric pressure drops. During the passage of the front, nimbostratus and cumulonimbus clouds predominate, and towering cumulus clouds may also form. Light to heavy precipitation falls, visibility is poor, winds are variable, and the barometric pressure levels off. After the passage of the front, nimbostratus and altostratus clouds are visible, precipitation decreases, and visibility improves.

Thunderstorms

A thunderstorm makes its way through three distinct stages before dissipating. It begins with the cumulus stage, in which lifting action of the air begins. If sufficient moisture and instability are present, the clouds continue to increase in vertical height. Continuous, strong updrafts prohibit moisture from falling. Within approximately 15 minutes, the thunderstorm reaches the mature stage, which is the most violent time period of the thunderstorm's life cycle. At this point, drops of moisture, whether rain or ice, are too heavy for the cloud to support and begin falling in the form of rain or hail. This creates a downward motion of the air. Warm, rising air; cool, precipitation-induced descending air; and violent turbulence all exist within and near the cloud. Below the cloud, the down-rushing air increases surface winds and decreases the temperature. Once the vertical motion near the top of the cloud slows down, the top of the cloud spreads out and takes on an anvil-like shape. At this point, the storm enters the dissipating stage. This is when the downdrafts spread out and replace the updrafts needed to sustain the storm.

It is impossible to fly over thunderstorms in light aircraft. Severe thunderstorms can punch through the tropopause and reach staggering heights of 50,000 to 60,000 feet depending on latitude. Flying under thunderstorms can subject aircraft to rain, hail, damaging lightning, and violent turbulence. A good rule of thumb is to circumnavigate thunderstorms identified as severe or giving an extreme radar echo by at least 20 nautical miles (NM) since hail may fall for miles outside of the clouds. If flying around a thunderstorm is not an option, stay on the ground until it passes.

For a thunderstorm to form, the air must have sufficient water vapor, an unstable lapse rate, and an initial lifting action to start the storm process. Some storms occur at random in unstable air, last for only an hour or two, and produce only moderate wind gusts and rainfall. These are known as air mass thunderstorms and are generally a result of surface heating. Steady-state thunderstorms are associated with weather systems. Fronts, converging winds, and troughs aloft force upward motion spawning these storms that often form into squall lines. In the mature stage, updrafts become stronger and last much longer than in air mass storms, hence the name steady state. *[Figure 12-29]*

Knowledge of thunderstorms and the hazards associated with them is critical to the safety of flight.

Hazards
All thunderstorms have conditions that are a hazard to aviation. These hazards occur in numerous combinations. While not every thunderstorm contains all hazards, it is not possible to visually determine which hazards a thunderstorm contains.

Turbulence
Potentially hazardous turbulence is present in all thunderstorms, and a severe thunderstorm can destroy an aircraft. Strongest turbulence within the cloud occurs with shear between updrafts and downdrafts. Outside the cloud, shear turbulence has been encountered several thousand feet above and 20 miles laterally from a severe storm. A low-level turbulent area is the shear zone associated with the gust front. Often, a “roll cloud” on the leading edge of a storm marks the top of the eddies in this shear, and it signifies an extremely turbulent zone. Gust fronts often move far ahead (up to 15 miles) of associated precipitation. The gust front causes a rapid, and sometimes drastic, change in surface wind ahead.

Hail
Hail competes with turbulence as the greatest thunderstorm hazard to aircraft. Supercooled drops above the freezing level begin to freeze. Once a drop has frozen, other drops latch on and freeze to it, so the hailstone grows—sometimes into a huge ice ball. Large hail occurs with severe thunderstorms with strong updrafts that have built to great heights. Eventually, the hailstones fall, possibly some distance from the storm core. Hail may be encountered in clear air several miles from thunderstorm clouds.

As hailstones fall through air whose temperature is above 0°C, they begin to melt and precipitation may reach the ground as either hail or rain. Rain at the surface does not mean the absence of hail aloft. Possible hail should be anticipated with any thunderstorm, especially beneath the anvil of a large cumulonimbus. Hailstones larger than one-half inch in diameter can significantly damage an aircraft in a few seconds.

Ceiling and Visibility

Generally, visibility is near zero within a thunderstorm cloud. Ceiling and visibility also may be restricted in precipitation and dust between the cloud base and the ground. The restrictions create the same problem as all ceiling and visibility restrictions; but the hazards are multiplied when associated with the other thunderstorm hazards of turbulence, hail, and lightning.

Effect on Altimeters

Pressure usually falls rapidly with the approach of a thunderstorm, rises sharply with the onset of the first gust and arrival of the cold downdraft and heavy rain showers, and then falls back to normal as the storm moves on. This cycle of pressure change may occur in 15 minutes. If the pilot does not receive a corrected altimeter setting, the altimeter may be more than 100 feet in error.

Lightning

A lightning strike can puncture the skin of an aircraft and damage communications and electronic navigational equipment. Although lightning has been suspected of igniting fuel vapors and causing an explosion, serious accidents due to lightning strikes are rare. Nearby lightning can blind the pilot, rendering him or her momentarily unable to navigate either by instrument or by visual reference. Nearby lightning can also induce permanent errors in the magnetic compass. Lightning discharges, even distant ones, can disrupt radio communications on low and medium frequencies. Though lightning intensity and frequency have no simple relationship to other storm parameters, severe storms, as a rule, have a high frequency of lightning.

Chapter Summary

Knowledge of the atmosphere and the forces acting within it to create weather is essential to understand how weather affects a flight. By understanding basic weather theories, a pilot can make sound decisions during flight planning after receiving weather briefings. For additional information on the topics discussed in this chapter, see the following publications as amended: AC 00-6, Aviation Weather For Pilots and Flight Operations Personnel; AC 00-24, Thunderstorms; AC 00-45, Aviation Weather Services; AC 91-74, Pilot Guide: Flight in Icing Conditions; and chapter 7, section 2 of the Aeronautical Information Manual (AIM).

Weather Briefings

Prior to every flight, pilots should gather all information vital to the nature of the flight. This includes an appropriate weather briefing obtained from a specialist at a FSS.

For weather specialists to provide an appropriate weather briefing, they need to know which of the three types of briefings is needed—standard, abbreviated, or outlook. Other helpful information is whether the flight is visual flight rules (VFR) or IFR, aircraft identification and type, departure point, estimated time of departure (ETD), flight altitude, route of flight, destination, and estimated time en route (ETE).

This information is recorded in the flight plan system and a note is made regarding the type of weather briefing provided. If necessary, it can be referenced later to file or amend a flight plan. It is also used when an aircraft is overdue or is reported missing.

Standard Briefing

A standard briefing provides the most complete information and a more complete weather picture. This type of briefing should be obtained prior to the departure of any flight and should be used during flight planning.

A standard briefing provides the following information in sequential order if it is applicable to the route of flight.

- Adverse conditions—this includes information about adverse conditions that may influence a decision to cancel or alter the route of flight. Adverse conditions include significant weather, such as thunderstorms or aircraft icing, or other important items such as airport closings.
- VFR flight not recommended—if the weather for the route of flight is below VFR minimums, or if it is doubtful the flight could be made under VFR conditions due to the forecast weather, the briefer may state "VFR flight not recommended." It is the pilot's decision whether or not to continue the flight under VFR, but this advisory should be weighed carefully.
- Synopsis—an overview of the larger weather picture. Fronts and major weather systems that affect the general area are provided.
- Current conditions—the current ceilings, visibility, winds, and temperatures. If the departure time is more than 2 hours away, current conditions are not included in the briefing.
- En route forecast—a summary of the weather forecast for the proposed route of flight.
- Destination forecast—a summary of the expected weather for the destination airport at the estimated time of arrival (ETA).
- Forecast winds and temperatures aloft—a forecast of the winds at specific altitudes for the route of flight. The forecast temperature information aloft is provided only upon request.
- Notices to Airmen (NOTAM)—information pertinent to the route of flight that has not been published in the NOTAM publication. Published NOTAM information is provided during the briefing only when requested.
- ATC delays—an advisory of any known ATC delays that may affect the flight.
- Other information—at the end of the standard briefing, the FSS specialist provides the radio frequencies needed to open a flight plan and to contact EFAS. Any additional information requested is also provided at this time.

Abbreviated Briefing
An abbreviated briefing is a shortened version of the standard briefing. It should be requested when a departure has been delayed or when weather information is needed to update the previous briefing. When this is the case, the weather specialist needs to know the time and source of the previous briefing so the necessary weather information is not omitted inadvertently. It is always a good idea for the pilot to update the weather information whenever he/she has additional time.

Outlook Briefing
An outlook briefing should be requested when a planned departure is 6 hours or more away. It provides initial forecast information that is limited in scope due to the time frame of the planned flight. This type of briefing is a good source of flight planning information that can influence decisions regarding route of flight, altitude, and ultimately the go/no-go decision. A prudent pilot requests a follow-up briefing prior to departure since an outlook briefing generally only contains information based on weather trends and existing weather in geographical areas at or near the departure airport. A standard briefing near the time of departure ensures that the pilot has the latest information available prior to his/her flight.

Aviation Weather Reports

Aviation weather reports are designed to give accurate depictions of current weather conditions. Each report provides current information that is updated at different times. Some typical reports are METARs and PIREPs.

Aviation Routine Weather Report (METAR)
A METAR is an observation of current surface weather reported in a standard international format. While the METAR code has been adopted worldwide, each country is allowed to make modifications to the code. Normally, these differences are minor but necessary to accommodate local procedures or particular units of measure. This discussion of METAR covers elements used in the United States.

METARs are issued on a regularly scheduled basis unless significant weather changes have occurred. A special METAR (SPECI) can be issued at any time between routine METAR reports.

Example:
METAR KGGG 161753Z AUTO 14021G26KT 3/4SM
+TSRA BR BKN008 OVC012CB 18/17 A2970 RMK PRESFR

A typical METAR report contains the following information in sequential order:

- Type of report—there are two types of METAR reports. The first is the routine METAR report that is transmitted on a regular time interval. The second is the aviation selected SPECI. This is a special report that can be given at any time to update the METAR for rapidly changing weather conditions, aircraft mishaps, or other critical information.
- Station identifier—a four-letter code as established by the International Civil Aviation Organization (ICAO). In the 48 contiguous states, a unique three-letter identifier is preceded by the letter "K." For example, Gregg County Airport in Longview, Texas, is identified by the letters "KGGG," K being the country designation and GGG being

the airport identifier. In other regions of the world, including Alaska and Hawaii, the first two letters of the four-letter ICAO identifier indicate the region, country, or state. Alaska identifiers always begin with the letters "PA" and Hawaii identifiers always begin with the letters "PH." Station identifiers can be found by calling the FSS, a NWS office, or by searching various websites such as DUATS and NOAA's Aviation Weather Aviation Digital Data Services (ADDS).

- Date and time of report—depicted in a six-digit group (161753Z). The first two digits are the date. The last four digits are the time of the METAR/SPECI, which is always given in coordinated universal time (UTC). A "Z" is appended to the end of the time to denote the time is given in Zulu time (UTC) as opposed to local time.
- Modifier—denotes that the METAR/SPECI came from an automated source or that the report was corrected. If the notation "AUTO" is listed in the METAR/SPECI, the report came from an automated source. It also lists "AO1" (for no precipitation discriminator) or "AO2" (with precipitation discriminator) in the "Remarks" section to indicate the type of precipitation sensors employed at the automated station. When the modifier "COR" is used, it identifies a corrected report sent out to replace an earlier report that contained an error (for example: METAR KGGG 161753Z COR).
- Wind—reported with five digits (14021KT) unless the speed is greater than 99 knots, in which case the wind is reported with six digits. The first three digits indicate the direction the true wind is blowing from in tens of degrees. If the wind is variable, it is reported as "VRB." The last two digits indicate the speed of the wind in knots unless the wind is greater than 99 knots, in which case it is indicated by three digits. If the winds are gusting, the letter "G" follows the wind speed (G26KT). After the letter "G," the peak gust recorded is provided. If the wind direction varies more than 60° and the wind speed is greater than six knots, a separate group of numbers, separated by a "V," will indicate the extremes of the wind directions.
- Visibility—the prevailing visibility (¾ SM) is reported in statute miles as denoted by the letters "SM." It is reported in both miles and fractions of miles. At times, runway visual range (RVR) is reported following the prevailing visibility. RVR is the distance a pilot can see down the runway in a moving aircraft. When RVR is reported, it is shown with an R, then the runway number followed by a slant, then the visual range in feet. For example, when the RVR is reported as R17L/1400FT, it translates to a visual range of 1,400 feet on runway 17 left.
- Weather—can be broken down into two different categories: qualifiers and weather phenomenon (+TSRA BR). First, the qualifiers of intensity, proximity, and the descriptor of the weather are given. The intensity may be light (–), moderate ( ), or heavy (+). Proximity only depicts weather phenomena that are in the airport vicinity. The notation "VC" indicates a specific weather phenomenon is in the vicinity of five to ten miles from the airport. Descriptors are used to describe certain types of precipitation and obscurations. Weather phenomena may be reported as being precipitation, obscurations, and other phenomena, such as squalls or funnel clouds. Descriptions of weather phenomena as they begin or end and hailstone size are also listed in the "Remarks" sections of the report.
- Sky condition—always reported in the sequence of amount, height, and type or indefinite ceiling/height (vertical visibility) (BKN008 OVC012CB, VV003). The heights of the cloud bases are reported with a three-digit number in hundreds of feet AGL. Clouds above 12,000 feet are not detected or reported by an automated station. The

types of clouds, specifically towering cumulus (TCU) or cumulonimbus (CB) clouds, are reported with their height. Contractions are used to describe the amount of cloud coverage and obscuring phenomena. The amount of sky coverage is reported in eighths of the sky from horizon to horizon. [Figure 4-8]

- Temperature and dew point—the air temperature and dew point are always given in degrees Celsius (C) or (18/17). Temperatures below 0 °C are preceded by the letter "M" to indicate minus.
- Altimeter setting—reported as inches of mercury ("Hg) in a four-digit number group (A2970). It is always preceded by the letter "A." Rising or falling pressure may also be denoted in the "Remarks" sections as "PRESRR" or "PRESFR," respectively.
- Zulu time—a term used in aviation for UTC, which places the entire world on one time standard
- Remarks—the remarks section always begins with the letters "RMK." Comments may or may not appear in this section of the METAR. The information contained in this section may include wind data, variable visibility, beginning and ending times of particular phenomenon, pressure information, and various other information deemed necessary. An example of a remark regarding weather phenomenon that does not fit in any other category would be: OCNL LTGICCG. This translates as occasional lightning in the clouds and from cloud to ground. Automated stations also use the remarks section to indicate the equipment needs maintenance.

The weather groups are constructed by considering columns 1–5 in this table in sequence: intensity, followed by descriptor, followed by weather phenomena (e.g., heavy rain showers(s) is coded as +SHRA).
** Automated stations only*

Qualifier		Weather Phenomena		
Intensity or Proximity 1	Descriptor 2	Precipitation 3	Obscuration 4	Other 5
- Light	**MI** Shallow	**DZ** Drizzle	**BR** Mist	**PO** Dust/sand whirls
Moderate (no qualiÞer)	**BC** Patches	**RA** Rain	**FG** Fog	**SQ** Squalls
+ Heavy	**DR** Low drifting	**SN** Snow	**FU** Smoke	**FC** Funnel cloud
VC in the vicinity	**BL** Blowing	**SG** Snow grains	**DU** Dust	**+FC** Tornado or waterspout
	SH Showers	**IC** Ice crystals (diamond dust)	**SA** Sand	**SS** Sandstorm
	TS Thunderstorms	**PL** Ice pellets	**HZ** Haze	**DS** Dust storm
	FZ Freezing	**GR** Hail	**PY** Spray	
	PR Partial	**GS** Small hail or snow pellets	**VA** Volcanic ash	
		UP *Unknown precipitation		

The weather groups are constructed by considering columns 1-5 in this table in sequence:
intensity, followed by descriptor, followed by weather phenomena (e.g., heavy rain showers(s) is coded as +SHRA).
* Automated stations only

Figure 4-8. Descriptors and weather phenomena used in a typical METAR.

Many of the current fixed wing pilot focuses weather services do not necessarily fit into what ultralight pilots would typically look at, but it is worth knowing there are options surrounding general aviation that you can utilize. Roll back to earlier topic in this chapter regarding skew t plots, noaa daily aviation discussions, skysight, xc skies, and 1800 WX Brief.

Weather Charts

Weather charts are graphic charts that depict current or forecast weather. They provide an overall picture of the United States and should be used in the beginning stages of flight planning. Typically, weather charts show the movement of major weather systems and fronts. Surface analysis, weather depiction, and significant weather prognostic charts are sources of current weather information. Significant weather prognostic charts provide an overall forecast weather picture.

Surface Analysis Chart

The surface analysis chart depicts an analysis of the current surface weather. [Figure 4-9] This chart is transmitted every 3 hours and covers the contiguous 48 states and adjacent areas. A surface analysis chart shows the areas of high and low pressure, fronts, temperatures, dew points, wind directions and speeds, local weather, and visual obstructions. Surface weather observations for reporting points across the United States are also depicted on this chart. Each of these reporting points is illustrated by a station model. **A station model includes:**

- Sky cover—the station model depicts total sky cover and is shown as clear, scattered, broken, overcast, or obscured/partially obscured.
- Sea level pressure—given in three digits to the nearest tenth of a millibar (mb). For 1,000 mbs or greater, prefix a 10 to the three digits. For less than 1,000 mbs, prefix a 9 to the three digits.
- Pressure change/tendency—pressure change in tenths of mb over the past 3 hours. This is depicted directly below the sea level pressure.
- Dew point—given in degrees Fahrenheit.
- Present weather—over 100 different standard weather symbols are used to describe the current weather.
- Temperature—given in degrees Fahrenheit.
- Wind—true direction of wind is given by the wind pointer line, indicating the direction from which the wind is blowing. A short barb is equal to 5 knots of wind, a long barb is equal to 10 knots of wind, and a pennant is equal to 50 knots.

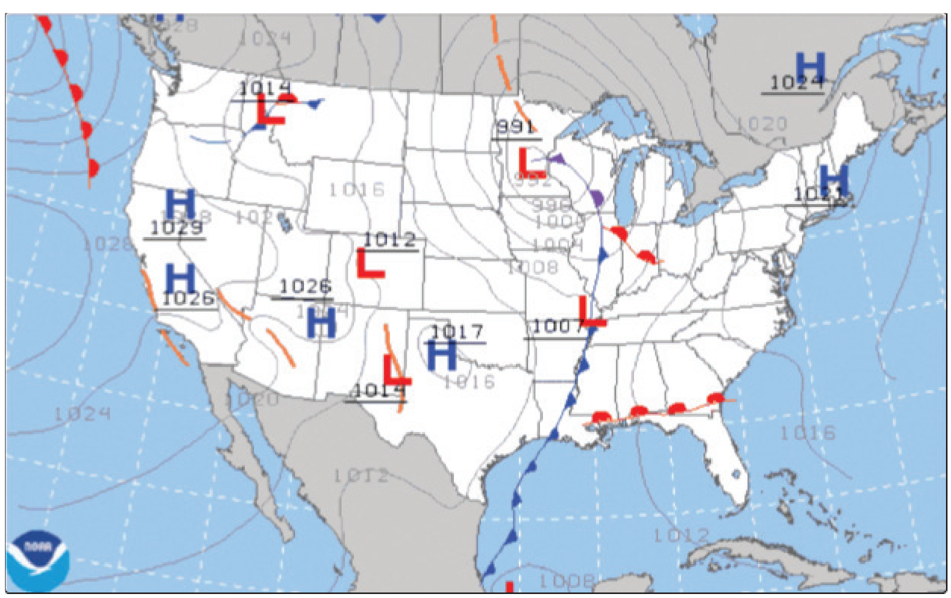


Figure 4-9. Surface analysis chart

Weather Depiction Chart

A weather depiction chart details surface conditions as derived from METAR and other surface observations. The weather depiction chart is prepared and transmitted by computer every 3 hours beginning at 0100Z time and is valid data for the forecast period. It is designed to be used for flight planning by giving an overall picture of the weather across the United States. [Figure 4-10]

The weather depiction chart also provides a graphic display of IFR, VFR, and marginal VFR (MVFR) weather. Areas of IFR conditions (ceilings less than 1,000 feet and visibility less than three miles) are shown by a hatched area outlined by a smooth line. MVFR regions (ceilings 1,000 to 3,000 feet, visibility 3 to 5 miles) are shown by a nonmatched area outlined by a smooth line. Areas of VFR (no ceiling or ceiling greater than 3,000 feet and visibility greater than five miles) are not outlined. Also plotted are fronts, troughs, and squall lines from the previous hours surface analysis chart.

Weather depiction charts show a modified station model that provides sky conditions in the form of total sky cover, ceiling height, weather, and obstructions to visibility, but does not include winds or pressure readings like the surface analysis chart. A bracket ( ]) symbol to the right of the station indicates the observation was made by an automated station.

Significant Weather Prognostic Charts

Significant weather prognostic charts are available for low- level significant weather from the surface to FL 240 (24,000 feet), also referred to as the 400 mb level and high-level significant weather from FL 250 to FL 630 (25,000 to 63,000 feet). The primary concern of this discussion is the low-level significant weather prognostic chart.

The low-level chart is a forecast of aviation weather hazards, primarily intended to be used as a guidance product for briefing the VFR pilot. The forecast domain covers the 48 contiguous states, southern Canada and the coastal waters for altitudes below 24,000 ft. Low altitude Significant Weather charts are issued four times daily and are valid at fixed times: 0000, 0600, 1200, and 1800 UTC. Each chart is divided on the left and right into 12 and 24 hour forecast intervals (based on the current NAM model available).

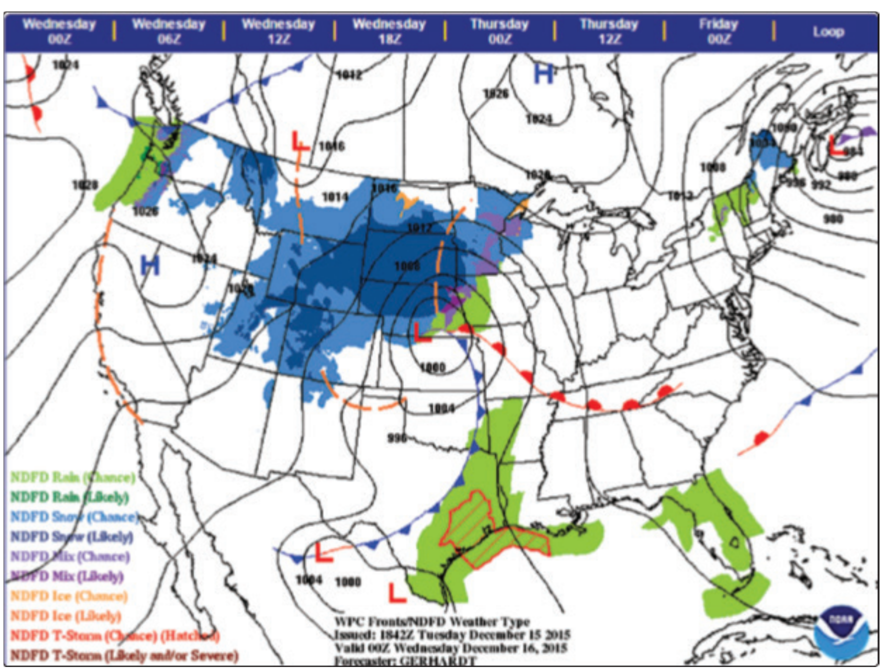


Figure 4-10. Weather depiction chart.

Effective September 1, 2015, the four-panel Low Level SFC-240 chart was replaced with a two-panel chart. The new two-panel chart will be the same as the top two panels in the former four-panel chart, depicting the freezing level and areas of IFR, MVFR, and moderate or greater turbulence. The bottom two panels of the chart have been removed. In lieu of these bottom two panels, an enhanced surface chart that includes fronts, pressure, precipitation type, precipitation intensity, and weather type, is displayed. The green precipitation polygons will be replaced by shaded precipitation areas using the National Digital Forecast Database (NDFD) weather grid.

Figure 13-13 depicts the new two-panel significant weather prognostic chart, as well as the symbols typically used to depict precipitation. The two panels depict freezing levels, turbulence, and low cloud ceilings and/or restrictions to visibility (shown as contoured areas of MVFR and IFR conditions). These charts enable the pilot to pictorially evaluate existing and potential weather hazards they may encounter. Pilots can balance weather phenomena with their aircraft capability and skill set resulting in aeronautical decision-making appropriate to the flight. Prognostic charts are an excellent source of information for preflight planning; however, this chart should be viewed in light of current conditions and specific local area forecasts.

The 36- and 48-hour significant weather prognostic chart is an extension of the 12- and 24-hour forecast. This chart is issued twice a day. It typically contains forecast positions and characteristics of pressure patterns, fronts, and precipitation. An example of a 36- and 48-hour surface prognostic chart is shown in Figure 4-11.

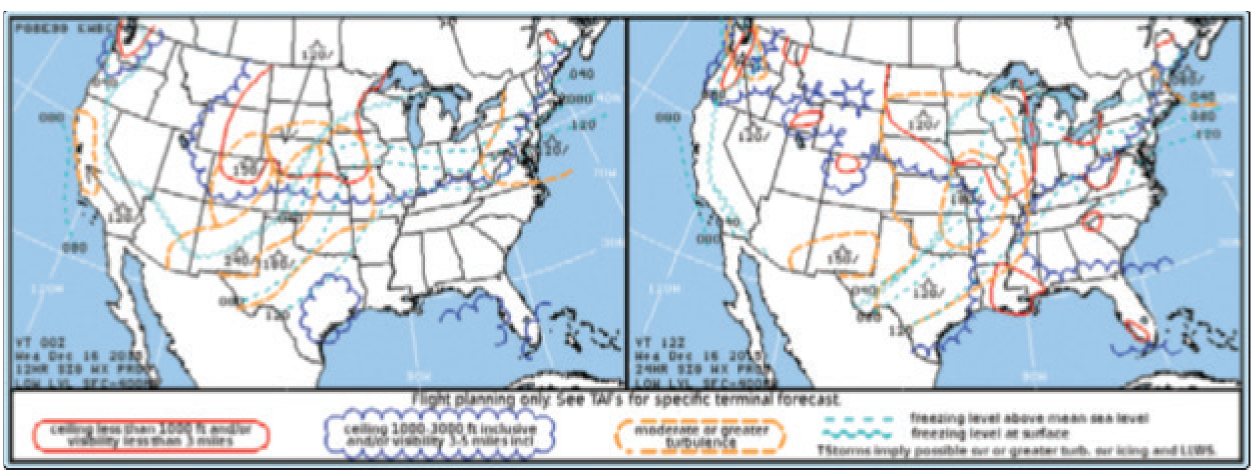
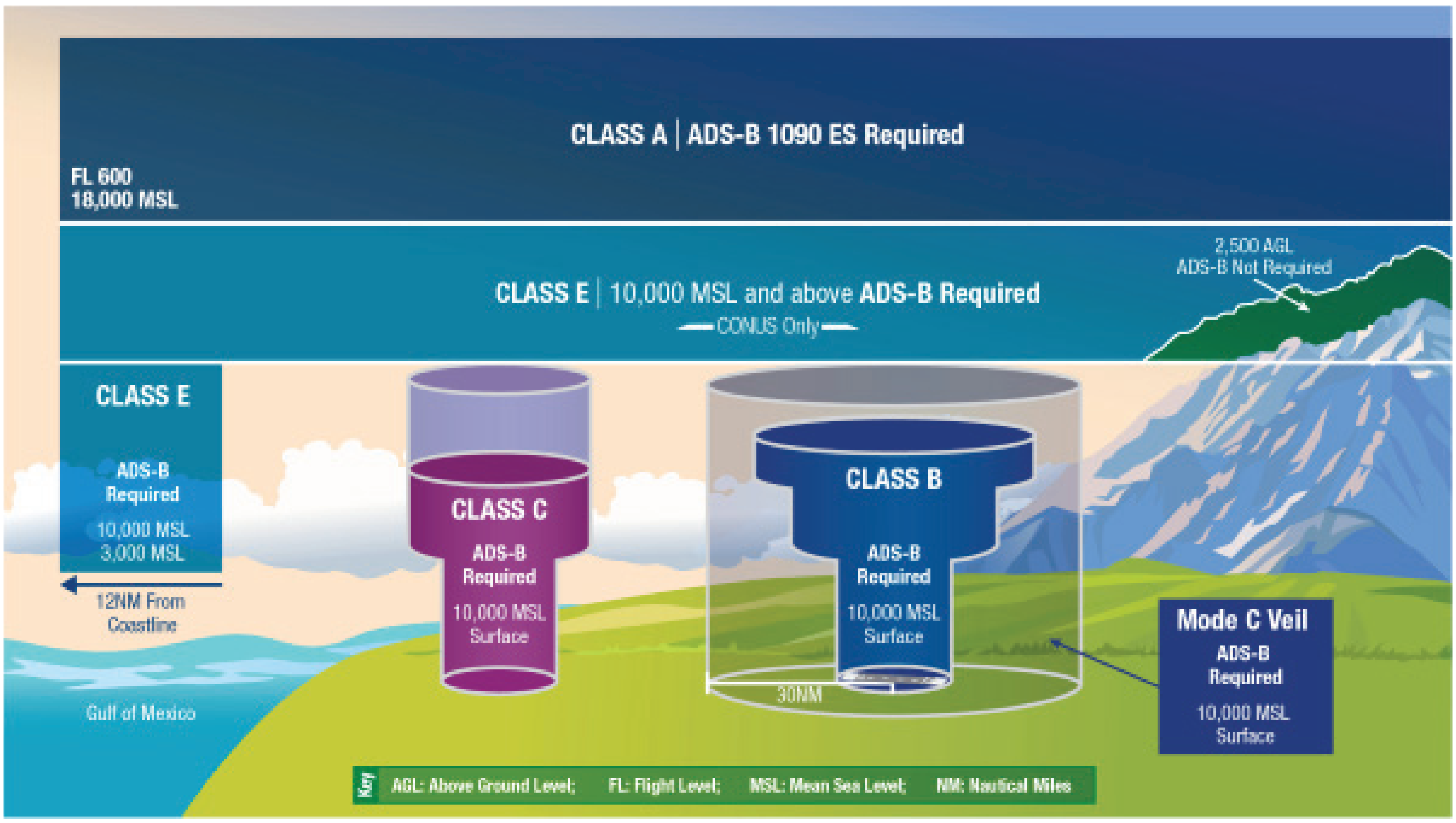


Figure 4-11. Significant weather prognostic chart.

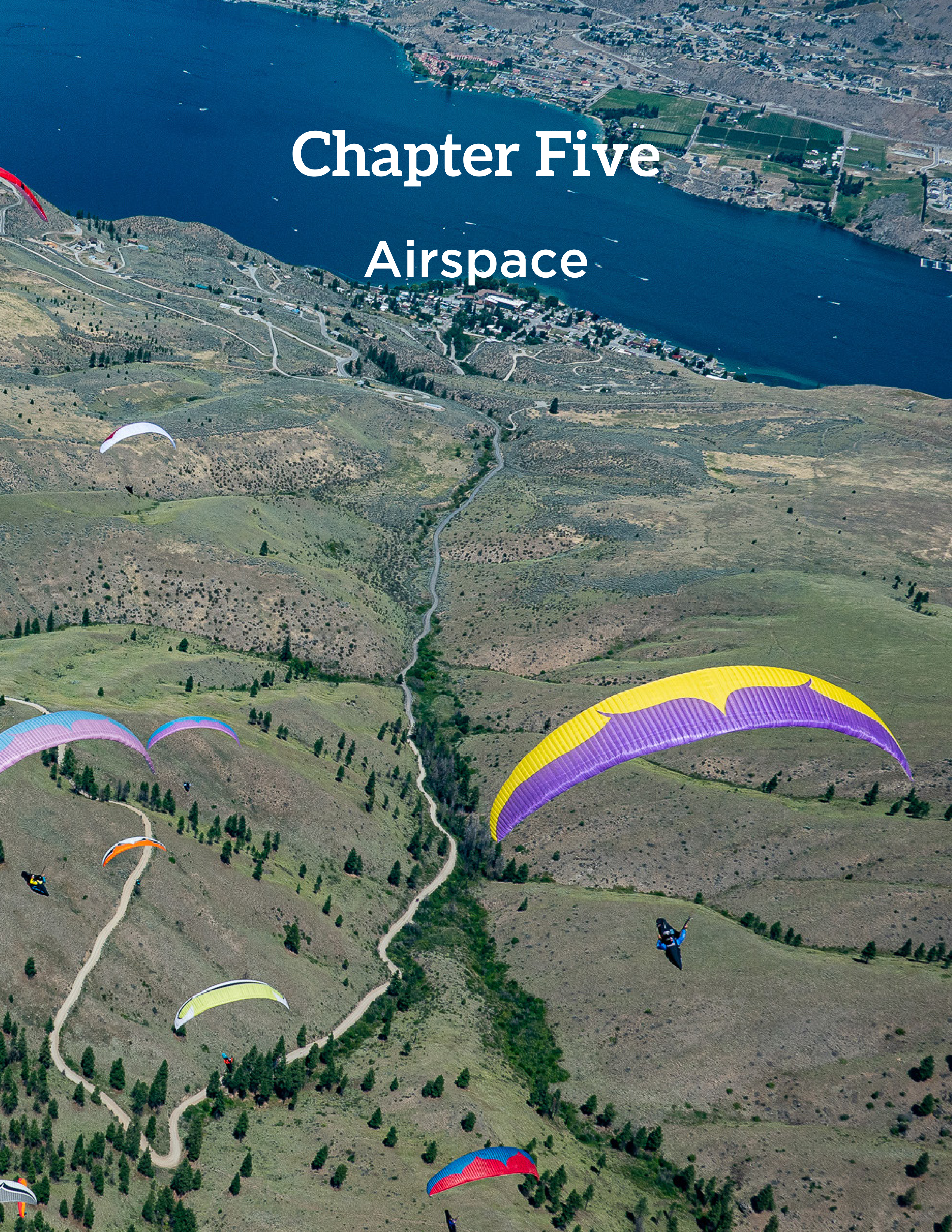
Chapter Summary

While no weather forecast is guaranteed to be 100 percent accurate, pilots have access to a myriad of weather information on which to base flight decisions. Weather products available for preflight planning to en-route information received over the radio or via data link provide the pilot with the most accurate and up-to-date information available. Each report provides a piece of the weather puzzle. Pilots must use several reports to get an overall picture and gain an understanding of the weather that affects the safe completion of a flight.



Chapter Five

Airspace



Controlled Airspace

Controlled airspace is a generic term that covers the different classifications of airspace and defined dimensions within which air traffic control (ATC) service is provided in accordance with the airspace classification.

Controlled airspace consists of:

Class A
Class B
Class C
Class D
Class E

Class A Airspace

Class A airspace is generally the airspace from 18,000 feet mean sea level (MSL) up to and including flight level (FL) 600, including the airspace overlying the waters within 12 nautical miles (NM) of the coast of the 48 contiguous states and Alaska. Unless otherwise authorized, all operation in Class A airspace is conducted under instrument flight rules (IFR).

Class B Airspace

Class B airspace is generally airspace from the surface to 10,000 feet MSL surrounding the nation's busiest airports in terms of airport operations or passenger enplanements. The configuration of each Class B airspace area is individually tailored, consists of a surface area and two or more layers (some Class B airspace areas resemble upside-down wedding cakes), and is designed to contain all published instrument procedures once an aircraft enters the airspace. ATC clearance is required for all aircraft to operate in the area, and all aircraft that are so cleared receive separation services within the airspace.

Class C Airspace

Class C airspace is generally airspace from the surface to 4,000 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower, are serviced by a radar approach control, and have a certain number of IFR operations or passenger enplanements. Although the configuration of each Class C area is individually tailored, the airspace usually consists of a surface area with a five NM radius, an outer circle with a ten NM radius that extends from 1,200 feet to 4,000 feet above the airport elevation. Each aircraft must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter must maintain those communications while within the airspace.

Class D Airspace

Class D airspace is generally airspace from the surface to 2,500 feet above the airport elevation (charted in MSL) surrounding those airports that have an operational control tower. The configuration of each Class D airspace area is individually tailored and, when instrument procedures are published, the airspace is normally designed to contain the procedures. Arrival extensions for instrument approach procedures (IAPs) may be Class

D or Class E airspace. Unless otherwise authorized, each aircraft must establish two-way radio communications with the ATC facility providing air traffic services prior to entering the airspace and thereafter maintain those communications while in the airspace.

Class E Airspace

Class E airspace is the controlled airspace not classified as Class A, B, C, or D airspace. A large amount of the airspace over the United States is designated as Class E airspace. This provides sufficient airspace for the safe control and separation of aircraft during IFR operations. Chapter 3 of the Aeronautical Information Manual (AIM) explains the various types of Class E airspace. Sectional and other charts depict all locations of Class E airspace with bases below 14,500 feet MSL. In areas where charts do not depict a class E base, class E begins at 14,500 feet MSL. In most areas, the Class E airspace base is 1,200 feet AGL. In many other areas, the Class E airspace base is either the surface or 700 feet AGL. Some Class E airspace begins at an MSL altitude depicted on the charts, instead of an AGL altitude. Class E airspace typically extends up to, but not including, 18,000 feet MSL (the lower limit of Class A airspace). All airspace above FL 600 is Class E airspace.

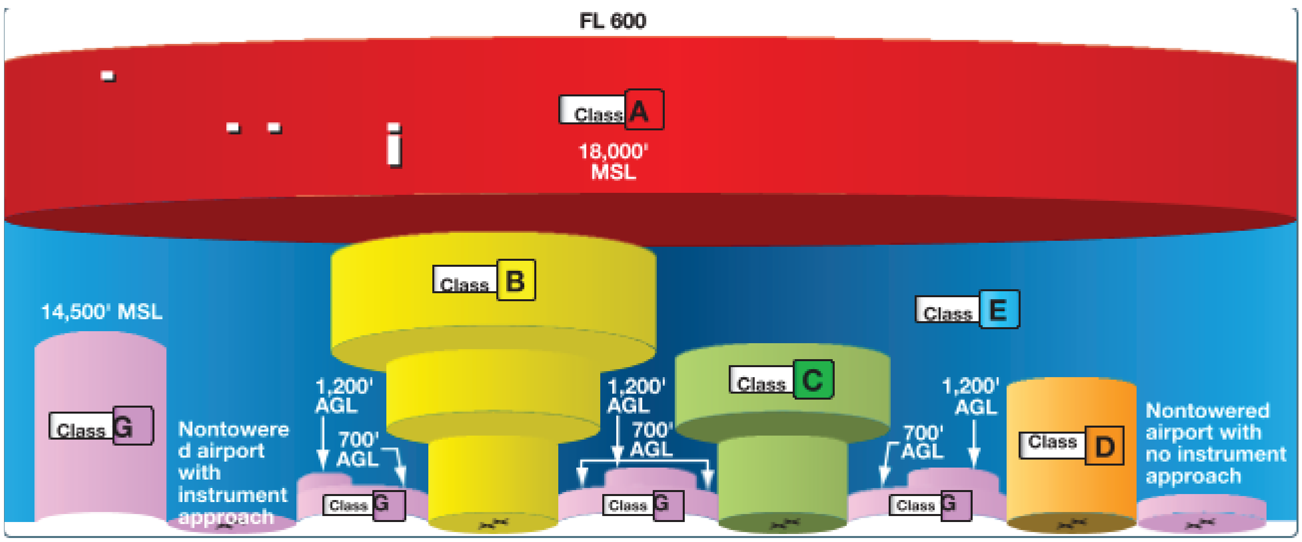


Figure 5-1. Airspace profile.

Uncontrolled Airspace

Class G Airspace

Uncontrolled airspace or Class G airspace is the portion of the airspace that has not been designated as Class A, B, C, D, or E. It is therefore designated uncontrolled airspace. Class G airspace extends from the surface to the base of the overlying Class E airspace. Although ATC has no authority or responsibility to control air traffic, pilots should remember there are visual flight rules (VFR) minimums that apply to Class G airspace.

Special Use Airspace

Special use airspace or special area of operation (SAO) is the designation for airspace in which certain activities must be confined, or where limitations may be imposed on aircraft operations that are not part of those activities. Certain special use airspace areas can create limitations on the mixed use of airspace. The special use airspace depicted on instrument charts includes the area name or number, effective altitude, time and weather conditions of operation, the controlling agency, and the chart panel location. On National Aeronautical Charting Group (NACG) en route charts, this information is available on one of the end panels.

Special use airspace usually consists of:

- Prohibited areas
- Restricted areas
- Warning areas
- Military operation areas (MOAs)
- Alert areas
- Controlled firing areas (CFAs)

Prohibited Areas

Prohibited areas contain airspace of defined dimensions within which the flight of aircraft is prohibited. Such areas are established for security or other reasons associated with the national welfare. These areas are published in the Federal Register and are depicted on aeronautical charts. The area is charted as a “P” followed by a number (e.g., P-40). Examples of prohibited areas include Camp David and the National Mall in Washington, D.C., where the White House and the Congressional buildings are located. [Figure 15-2]

Restricted Areas

Restricted areas are areas where operations are hazardous to nonparticipating aircraft and contain airspace within which the flight of aircraft, while not wholly prohibited, is subject to restrictions. Activities within these areas must be confined because of their nature, or limitations may be imposed upon aircraft operations that are not a part of those activities, or both. Restricted areas denote the existence of unusual, often invisible, hazards to aircraft (e.g., artillery firing, aerial gunnery, or guided missiles). IFR flights may be authorized to transit the airspace and are routed accordingly. Penetration of restricted areas without authorization from the using or controlling agency may be extremely hazardous to the aircraft and its occupants. ATC facilities apply the following procedures when aircraft are operating on an IFR clearance (including those cleared by ATC to maintain VFR on top) via a route that lies within joint-use restricted airspace:

- If the restricted area is not active and has been released to the Federal Aviation Administration (FAA), the ATC facility allows the aircraft to operate in the restricted airspace without issuing specific clearance for it to do so.
- If the restricted area is active and has not been released to the FAA, the ATC facility issues a clearance that ensures the aircraft avoids the restricted airspace.

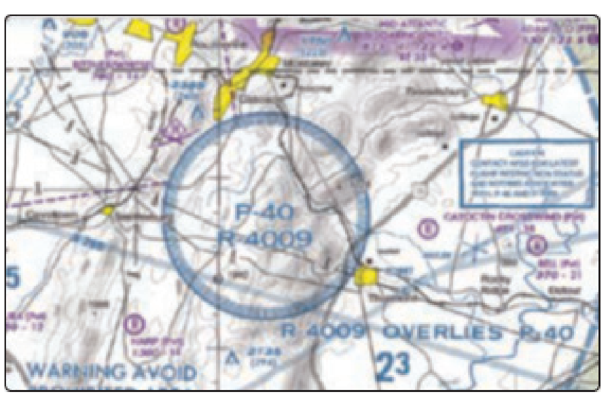


Figure 15-2. An example of a prohibited area, P-40 around Camp David.

Restricted areas are charted with an "R" followed by a number (e.g., R-4401) and are depicted on the en-route chart appropriate for use at the altitude or FL being flown. *[Figure 5-3]* Restricted area information can be obtained on the back of the chart.

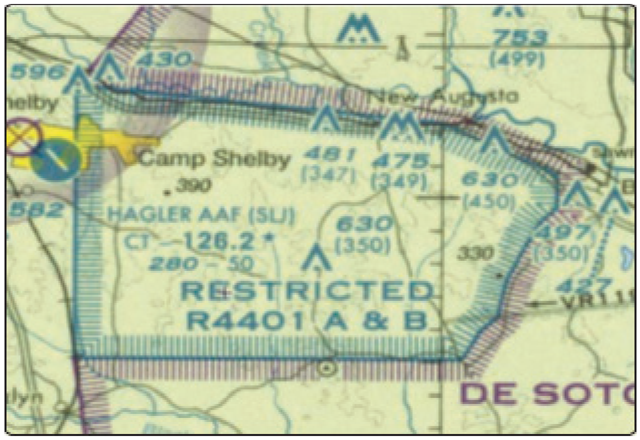


Figure 5-3. Restricted areas on a sectional chart.

Warning Areas

Warning areas are similar in nature to restricted areas; however, the United States government does not have sole jurisdiction over the airspace. A warning area is airspace of defined dimensions, extending from 3 NM outward from the coast of the United States, containing activity that may be hazardous to nonparticipating aircraft. The purpose of such areas is to warn nonparticipating pilots of the potential danger. A warning area may be located over domestic or international waters or both. The airspace is designated with a "W" followed by a number (e.g., W-237). *[Figure 5-4]*

Figure 5-4. Requirements for airspace operations.

Military Operation Areas (MOAs)

MOAs consist of airspace with defined vertical and lateral limits established for the purpose of separating certain military training activities from IFR traffic. Whenever an MOA is being used, nonparticipating IFR traffic may be cleared through an MOA if IFR separation can be provided by ATC. Otherwise, ATC reroutes or restricts nonparticipating IFR traffic. MOAs are depicted on sectional, VFR terminal area, and en route low altitude charts and are not numbered (e.g., "Camden Ridge MOA"). *[Figure 5-5]* However, the MOA is also further defined on the back of the sectional charts with times of operation, altitudes affected, and the controlling agency.

Alert Areas
Alert areas are depicted on aeronautical charts with an "A" followed by a number (e.g., A-211) to inform nonparticipating pilots of areas that may contain a high volume of pilot training or an unusual type of aerial activity. Pilots should exercise caution in alert areas. All activity within an alert area shall be conducted in accordance with regulations, without waiver, and pilots of participating aircraft, as well as pilots transiting the area, shall be equally responsible for collision avoidance. *[Figure 5-6]*

Controlled Firing Areas (CFAs)
CFAs contain activities that, if not conducted in a controlled environment, could be hazardous to nonparticipating aircraft. The difference between CFAs and other special use airspace is that activities must be suspended when a spotter aircraft, radar, or ground lookout position indicates an aircraft might be approaching the area. There is no need to chart CFAs since they do not cause a nonparticipating aircraft to change its flight path.

Other Airspace Areas
"Other airspace areas" is a general term referring to the majority of the remaining airspace. It includes:

- Local airport advisory (LAA)
- Military training route (MTR)
- Temporary flight restriction (TFR)
- Parachute jump aircraft operations
- Published VFR routes
- Terminal radar service area (TRSA)
- National security area (NSA)
- Air Defense Identification Zones (ADIZ) land and water based and need for Defense VFR (DVFR) flight plan to operate VFR in this airspace
- Intercept Procedures and use of 121.5 for communication if not on ATC already
- Flight Restricted Zones (FRZ) in vicinity of Capitol and White House
- Special Awareness Training required by 14 CFR 91.161 for pilots to operate VFR within 60 NM of the Washington, DC VOR/DME
- Wildlife Areas/Wilderness Areas/National Parks and request to operate above 2,000 AGL
- National Oceanic and Atmospheric Administration (NOAA) Marine Areas off the coast with requirement to operate above 2,000 AGL
- Tethered Balloons for observation and weather recordings that extend on cables up to 60,000

Figure 5-5. Camden Ridge MOA is an example of a military operations area.

Figure 5-6. Alert area (A-211).

Local Airport Advisory (LAA)

An advisory service provided by Flight Service Station (FSS) facilities, which are located on the landing airport, using a discrete ground-to-air frequency or the tower frequency when the tower is closed. LAA services include local airport advisories, automated weather reporting with voice broadcasting, and a continuous Automated Surface Observing System (ASOS)/ Automated Weather Observing Station (AWOS) data display, other continuous direct reading instruments, or manual observations available to the specialist.

Military Training Routes (MTRs)

MTRs are routes used by military aircraft to maintain proficiency in tactical flying. These routes are usually established below 10,000 feet MSL for operations at speeds in excess of 250 knots. Some route segments may be defined at higher altitudes for purposes of route continuity. Routes are identified as IFR (IR), and VFR (VR), followed by a number. [Figure 15-7] MTRs with no segment above 1,500 feet AGL are identified by four number characters (e.g., IR1206, VR1207). MTRs that include one or more segments above 1,500 feet AGL are identified by three number characters (e.g., IR206, VR207). IFR low altitude en-route charts depict all IR routes and all VR routes that accommodate operations above 1,500 feet AGL. IR routes are conducted in accordance with IFR regardless of weather conditions. VFR sectional charts depict military training activities, such as IR, VR, MOA, restricted area, warning area, and alert area information.

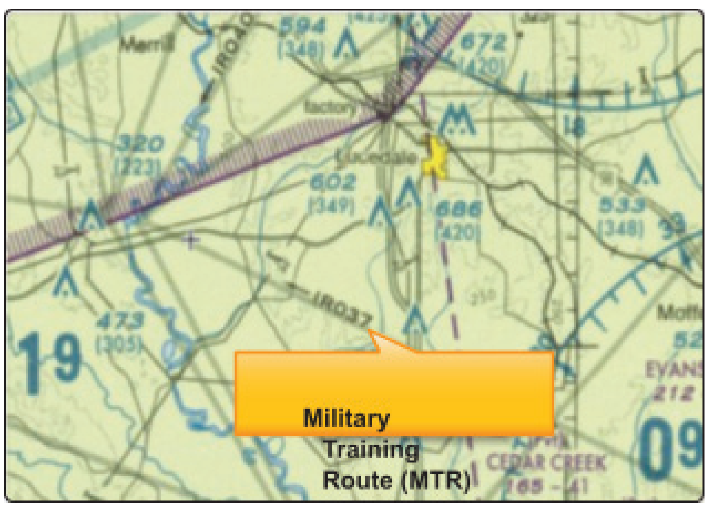


Figure 5-7. Military training route (MTR) chart symbols.

Temporary Flight Restrictions (TFR)

A flight data center (FDC) Notice to Airmen (NOTAM) is issued to designate a TFR. The NOTAM begins with the phrase "FLIGHT RESTRICTIONS" followed by the location of the temporary restriction, effective time period, area defined in statute miles, and altitudes affected. The NOTAM also contains the FAA coordination facility and telephone number, the reason for the restriction, and any other information deemed appropriate. The pilot should check the NOTAMs as part of flight planning.

Some of the purposes for establishing a TFR are:

Protect persons and property in the air or on the surface from an existing or imminent hazard.
Provide a safe environment for the operation of disaster relief aircraft.
Prevent an unsafe congestion of sightseeing aircraft above an incident or event, that may generate a high degree of public interest.
Protect declared national disasters for humanitarian reasons in the State of Hawaii.
Protect the President, Vice President, or other public figures.
Provide a safe environment for space agency operations.

Since the events of September 11, 2001, the use of TFRs has become much more common. There have been a number of incidents of aircraft incursions into TFRs that have resulted in pilots undergoing security investigations and certificate suspensions. It is a pilot's responsibility to be aware of TFRs in their proposed area of flight. One way to check is to visit the FAA website, www.tfr.faa.gov, and verify that there is not a TFR in the area.

Parachute Jump Aircraft Operations

Parachute jump aircraft operations are published in the Chart Supplement U.S. (formerly Airport/Facility Directory). Sites that are used frequently are depicted on sectional charts.

Published VFR Routes

Published VFR routes are for transitioning around, under, or through some complex airspace. Terms such as VFR flyway, VFR corridor, Class B airspace VFR transition route, and terminal area VFR route have been applied to such routes. These routes are generally found on VFR terminal area planning charts.

Terminal Radar Service Areas (TRSAs)

TRSAs are areas where participating pilots can receive additional radar services. The purpose of the service is toprovide separation between all IFR operations and participating VFR aircraft.

The primary airport(s) within the TRSA become(s) Class D airspace. The remaining portion of the TRSA overlies other controlled airspace, which is normally Class E airspace beginning at 700 or 1,200 feet and established to transition to/ from the en route/terminal environment. TRSAs are depicted on VFR sectional charts and terminal area charts with a solid black line and altitudes for each segment. The Class D portion is charted with a blue segmented line. Participation in TRSA services is voluntary; however, pilots operating under VFR are encouraged to contact the radar approach control and take advantage of TRSA service.

National Security Areas (NSAs)

NSAs consist of airspace of defined vertical and lateral dimensions established at locations where there is a requirement for increased security and safety of ground facilities. Flight in NSAs may be temporarily prohibited by regulation under the provisions of Title 14 of the Code of Federal Regulations (14 CFR) part 99, and prohibitions are disseminated via NOTAM. Pilots are requested to voluntarily avoid flying through these depicted areas.

Air Traffic Control and the National Airspace System

The primary purpose of the ATC system is to prevent a collision between aircraft operating in the system and to organize and expedite the flow of traffic. In addition to its primary function, the ATC system has the capability to provide (with certain limitations) additional services. The ability to provide additional services is limited by many factors, such as the volume of traffic, frequency congestion, quality of radar, controller workload, higher priority duties, and the pure physical inability to scan and detect those situations that fall in this category. It is recognized that these services cannot be provided in cases in which the provision of services is precluded by the above factors.

Consistent with the aforementioned conditions, controllers shall provide additional service procedures to the extent permitted by higher priority duties and other circumstances. The provision of additional services is not optional on the part of the controller, but rather is required when the work situation permits. Provide ATC service in accordance with the procedures and minima in this order except when:

- A deviation is necessary to conform to ICAO Documents, National Rules of the Air, or special agreements where the United States provides ATC service in airspace outside the country and its possessions
- Other procedures/minima are prescribed in a letter of agreement, FAA directive, or a military document
- A deviation is necessary to assist an aircraft when an emergency has been declared

Coordinating the Use of Airspace

ATC is responsible for ensuring that the necessary coordination has been accomplished before allowing an aircraft under their control to enter another controller's area of jurisdiction.

Before issuing control instructions directly or relaying through another source to an aircraft that is within another controller's area of jurisdiction that will change that aircraft's heading, route, speed, or altitude, ATC ensures that coordination has been accomplished with each of the controllers listed below whose area of jurisdiction is affected by those instructions unless otherwise specified by a letter of agreement or a facility directive:

- The controller within whose area of jurisdiction the control instructions are issued
- The controller receiving the transfer of control
- Any intervening controller(s) through whose area of jurisdiction the aircraft will pass

If ATC issues control instructions to an aircraft through a source other than another controller (e.g., Aeronautical Radio, Incorporated (ARINC), FSS, another pilot), they ensure that the necessary coordination has been accomplished with any controllers listed above, whose area of jurisdiction is affected by those instructions unless otherwise specified by a letter of agreement or a facility directive.

Operating in the Various Types of Airspace

It is important that pilots be familiar with the operational requirements for each of the various types or classes of airspace. Subsequent sections cover each class in sufficient detail to facilitate understanding regarding weather, type of pilot certificate held, and equipment required.

Basic VFR Weather Minimums

No pilot may operate an aircraft under basic VFR when the flight visibility is less, or at a distance from clouds that is less, than that prescribed for the corresponding altitude and class of airspace.]Except as provided in 14 CFR part 91, section 91.157, "Special VFR Weather Minimums," no person may operate an aircraft beneath the ceiling under VFR within the lateral boundaries of controlled airspace designated to the surface for an airport when the ceiling is less than 1,000 feet. Additional information can be found in 14 CFR part 91, section 91.155(c).

Ultralight Vehicles

No person may operate an ultralight vehicle within Class A, Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport unless that person has prior authorization from the ATC facility having jurisdiction over that airspace. (See 14 CFR part 103.)

Lets drill down on what airspace means fro ultralight pilots. For this we tap into a great video by certified flight instructor,sail plane instructor, and paraglider pilot, Ty Gunnlaugsson.

Understanding airspace for ultralights:
https://www.youtube.com/watch?v=1ivjTmWxsEg

Understanding Airspace for Ultralight Pilots
By Jim Macklow

The Federal Aviation Administration, in the interest of public safety, has defined a set of regulations which control access to and the use of the area above ground in which people normally fly. The FARs (Federal Aviation Regulations) cover all flying activities, including general aviation, ultralight vehicles, ballooning, skydiving, and even operations in space. There is a regulation which covers any area someone might use for air travel.

In order to safely operate a paraglider, a good understanding of the airspace system is required. There are three broad categories of airspace of which we should be aware:

- Airspace we cannot enter
  - Over any congested area of a city, town, or settlement (FAR 103.15)
  - Over any open air assembly of persons (FAR 103.15)
- Airspace we can enter only with prior authorization from the controlling authority
  - Class A, B, C, D controlled airspace (FAR 103.17)
  - Lateral boundaries of Class E airspace designated for an airport (FAR 103.17)
  - Prohibited or restricted areas (FAR 103.19)
  - Areas designated in a Notice to Airmen (NOTAM) (FAR 103.20)
- Airspace we can enter without prior authorization from any controlling authority
  - Airspace not defined above (Class G and most of Class E)

Paraglider pilots are most interested in the third category, as that is where paragliders fly the most. However, to avoid confusion while reading the FARs, AIM (Aeronautical Information Manual), and charts it is best to learn about airspace, first by determining the airspace in which one's flight will take place, in order to determine whether there are any restrictions/

prohibitions in effect. FAR 103 is not written like many federal regulations. It does not explicitly say where we can fly, it only lists restrictions, allowing us to fly in the remainder.

The airspace system is similarly defined, with the end result that Airspace Class G is not really explicitly defined, except as the space left over after all the controlled airspace has been defined.

The FAA defines airspace in the FARs, AIM and charts which are produced by National Aeronautical Charting Office of the FAA. There are online resources for the FARs and AIM:

FAR: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&tpl=/ecfrbrowse/Title14/14cfr103_main_02.tpl
AIM: http://www.faa.gov/airports_airtraffic/air_traffic/publications/ATpubs/AIM/

Understanding the basics (charts, FARs, AIM)

Classes of Airspace

In order to understand where we can and cannot fly, we must have a firm understanding of the different airspaces and how to identify them on the charts produced by the FAA. The airspace is defined in several places:

FAR definition of airspace
AIM explanation of airspace
Changes which occur between official publishings of the FAR, AIM, and aeronautical charts are published in the Federal Register

If you wish to determine the exact location (by latitude/longitude) of any airspace, Victor airway, military operating area (etc. etc.), you can look up in FAA Order 7400.9S.

The chart below shows the different airspaces. The Class E airspace below 18000' is depicted in light blue. Class G (uncontrolled) is in white. Classes B, C, and D airspaces below 18000' are grey. The surface is depicted in brown. Note that the cloud clearance and visibility requirements are different depending on the mean sea level (MSL) altitude, above ground level (AGL) altitude, and the class of airspace. A text version is printed in FAR 103.23.

Since most of our flying is done in Class E and G airspace, we should first learn how to determine which airspace a flying site, LZ, or route lies. We need to know whether we are in Class G or E because the flight visibility and cloud clearance requirements differ.

Class G airspace is defined in the FARs as that airspace which is not controlled airspace. Thus, it is imperative to be able to identify airspace by looking at a wide area chart, sectional chart, or terminal air chart.

Identifying Classes of Airspace:

Class A: all airspace between 18000’ and 60000’. Not identified on charts. (mnemonic: Above everything)

Class B: airspace around large regional airports. Identified on charts by thick blue lines. (mnemonic: Big airport)

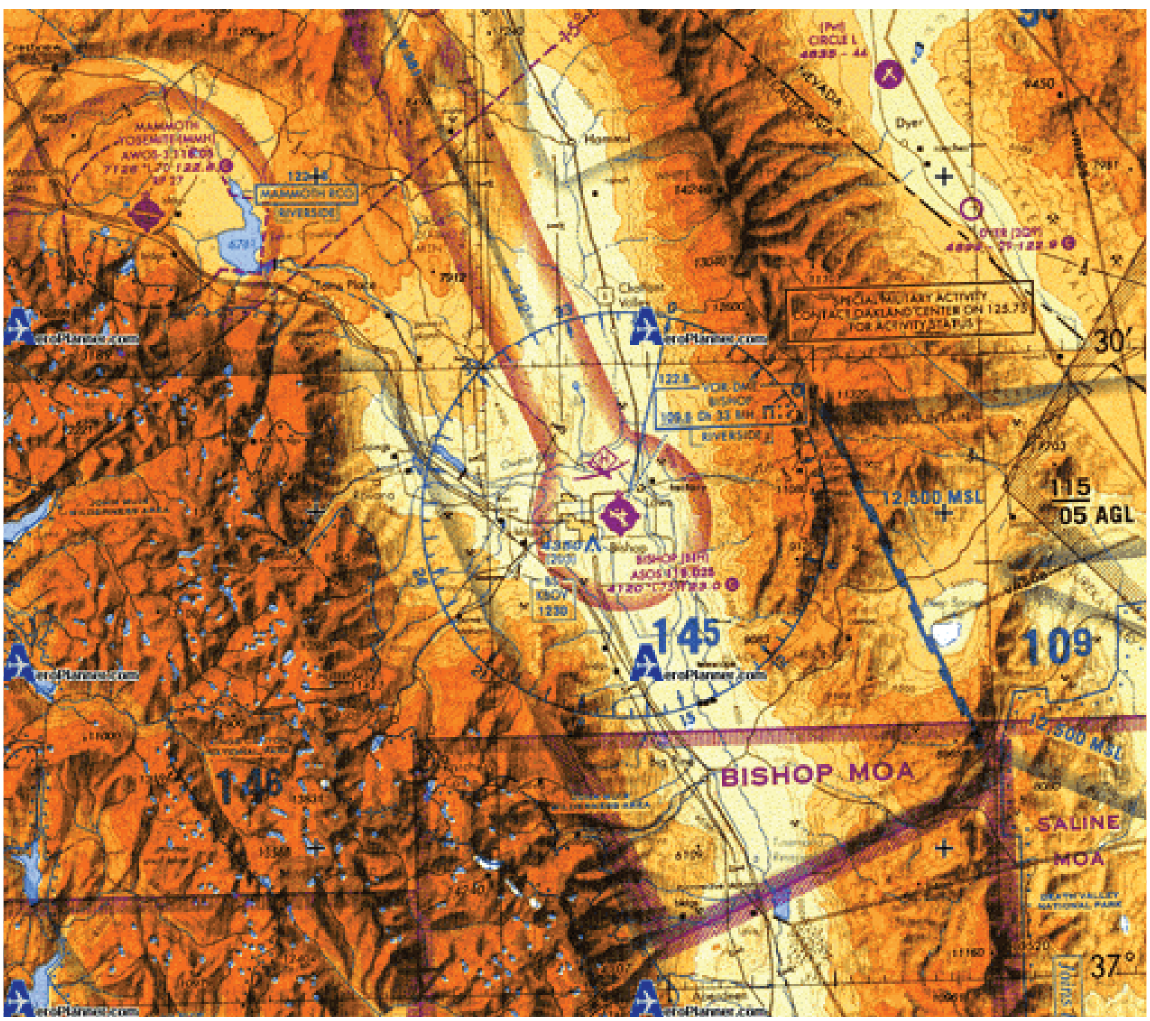
Class C: airspace around large city airports. Identified on charts by thick magenta lines. (mnemonic: City airport)

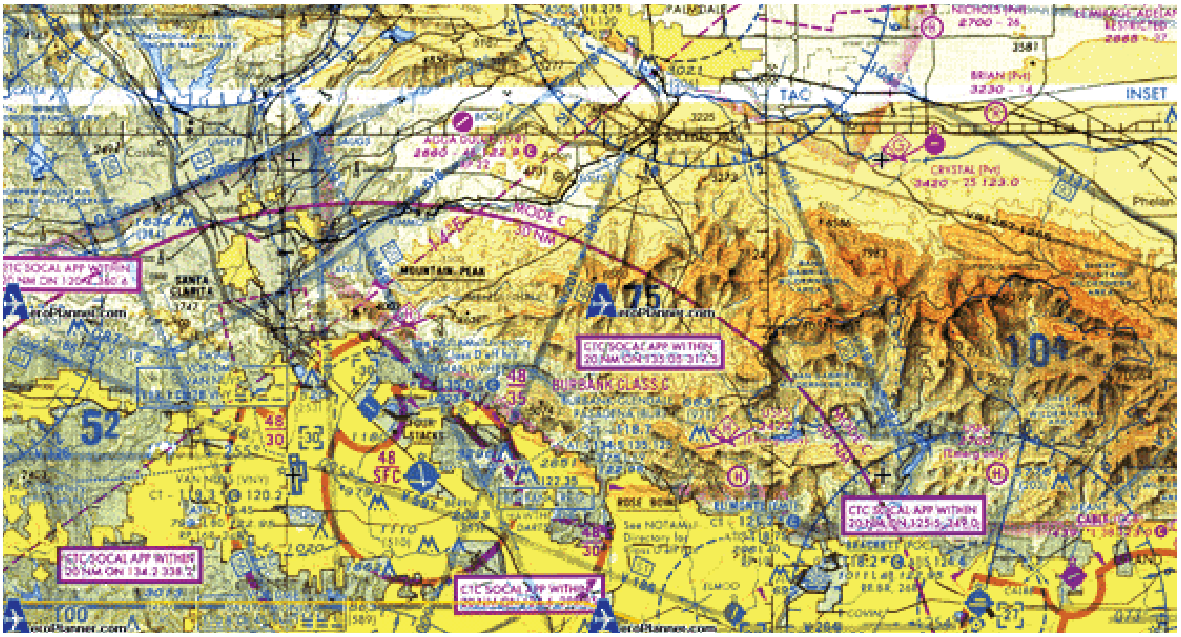
Class D: airspace around small airports. Identified on charts by blue dashed lines. (mnemonic: Dashed line)

Class G: uncontrolled airspace. From the ground up to the next overlying airspace (usually E). (mnemonic: near the Ground)

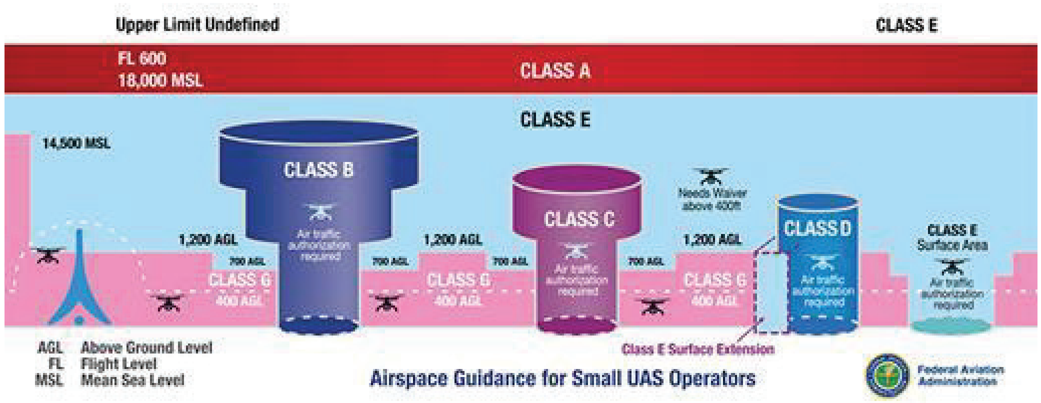
Class E: controlled airspace. Floor is 14,500’ MSL, and extends up to the next overlying airspace (A, B, C or D). (mnemonic: Everywhere else) Exceptions:

Class E floor is 1500’ AGL if surface is above 14,500’ MSL
Class E floor is 1200’ AGL (or more) if inside shaded blue line
Class E floor is 700’ AGL if inside shaded magenta line
Broken blue lines differentiate Class E floors when floor is above 700’ AGL

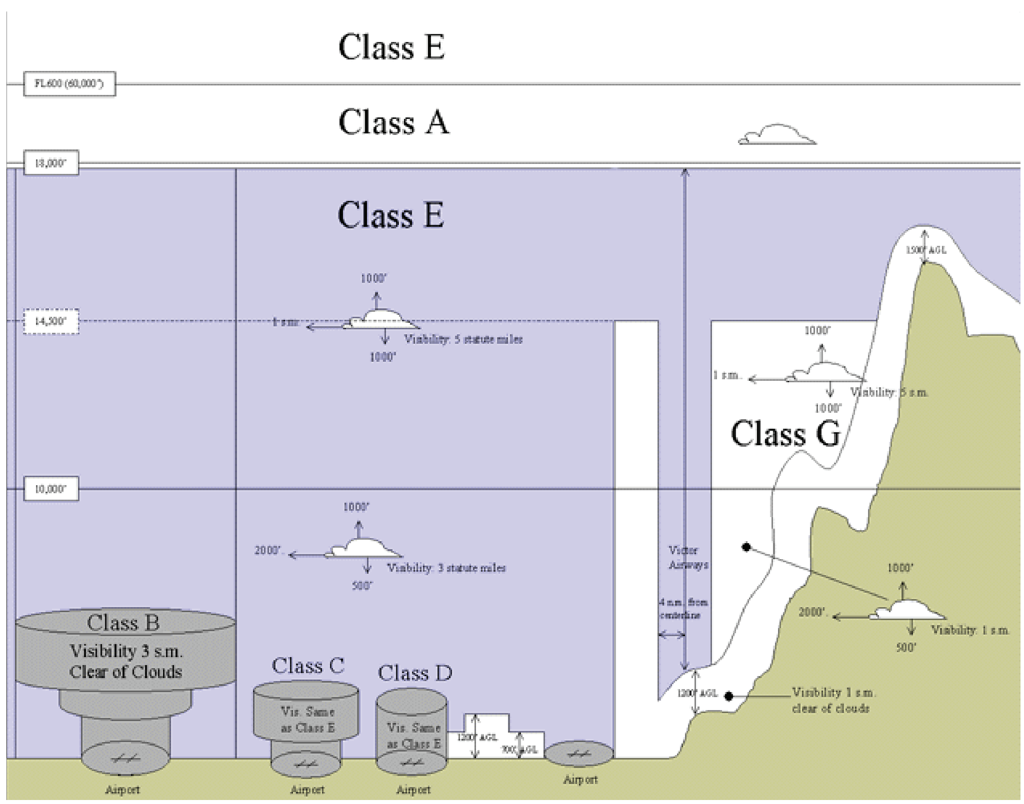




And one more airspace cake



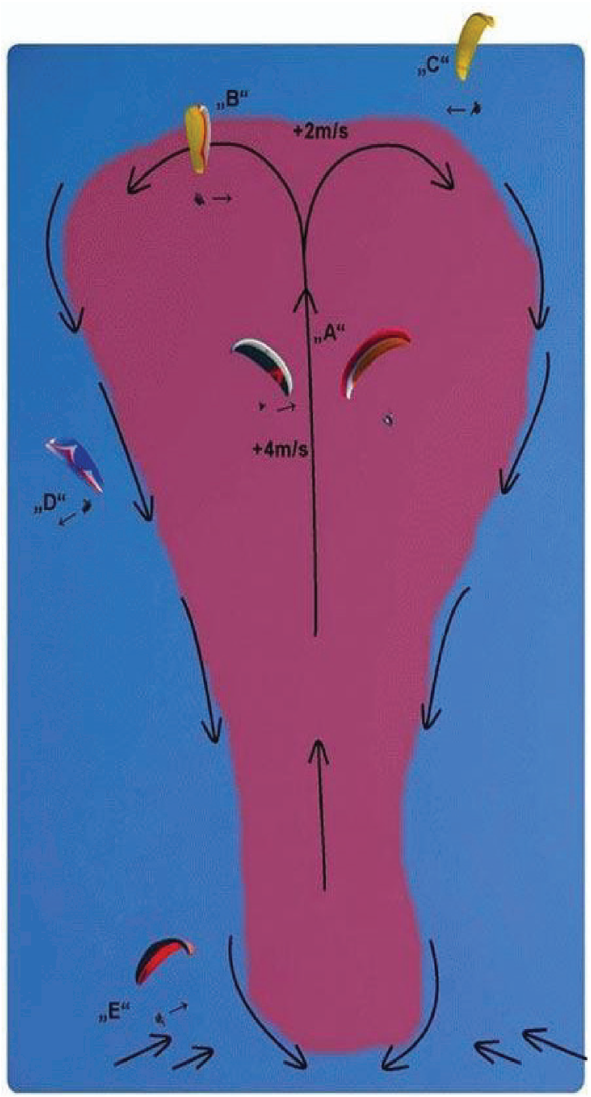
just in case you forgot!

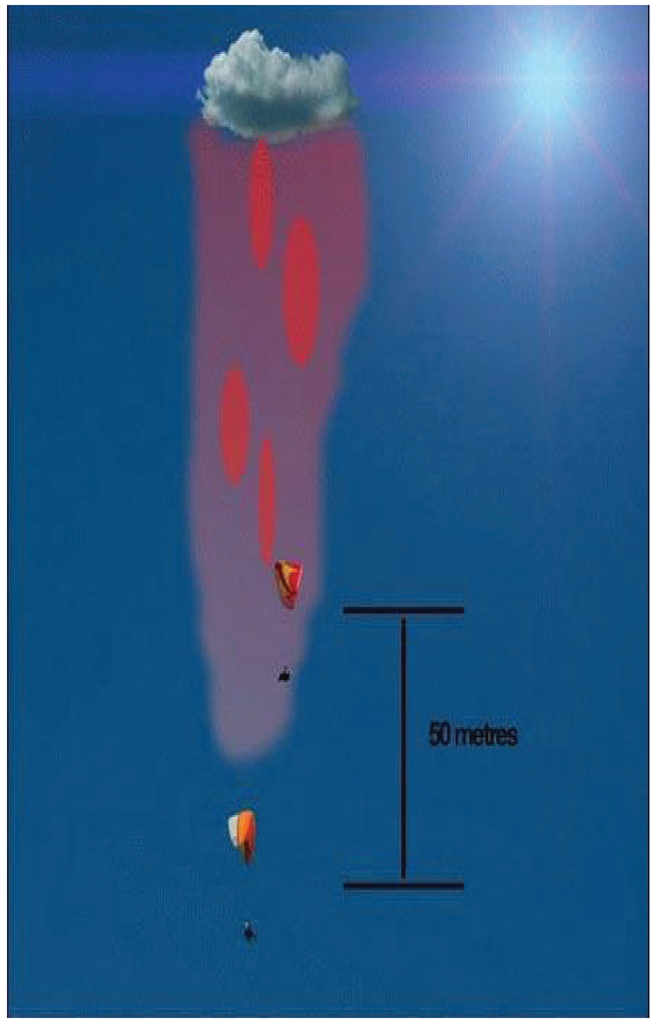


Chapter Six

Flying in Thermals

Thermal flying is an intermediate to advanced flying technique where the pilot will circle is raising columns of air to maintain or gain altitude. Often pilot's will utilize the thermal lift to fly cross country and travel long distances.





Thermals—Our Gas Stations in the Sky

The Five Star System by Bob Drury

Before you look at how best to use a thermal you first must find one. Thermals are invisible, so finding them is normally a process of stacking the odds in your favor. I teach pilots the 'Five Star' assessment system to help them increase the odds of finding a thermal.
It's a simple system that awards a rating to the place you are considering going to look for a thermal, based on how many of the following clues you can see there: sunshine, wind, landscape, cloud and birds or gliders. Let's look more closely at each clue to understand them.

The Sun

It's our fuel. Without it there is no radiation, no heating and no thermals. If you are flying on a day with clouds and shadows, the ground will be being heated in the areas of sunshine and not in the areas of shade.

Although shadows can trigger warm air to leave the ground as they pass overhead, as a general rule the shade is a pretty poor place to be for any soaring aircraft or bird. Former world champion, Rob Whittall, once told me when I pressed him for his single most important piece of advice, "If you stay in the sunshine, you'll not go far wrong." Award your potential thermal source one star if it's basking in sunshine.

Wind

Not only does it create dynamic lift on hillsides, which prolongs your flight and radically increase your chances of catching a climb, it also blows the thermals along the ground and up the hillside to the top where they trigger.

In proper mountain systems that are subject to valley winds and anabatic flows you should always remember that it's these lower winds that bring the warmed air from the valley up on to the mountains, the meteo wind is often of little real importance until you are high up. You should study the shape of the valley below and imagine a huge river is washing up the valley. The places where your river would collide with the landscape and be forced upwards are always good places to look for thermals.

In the flatlands things work a little differently. The wind blows the warmed air along the ground until it reaches a trigger point like a river, a line of trees, a road or simply an undulation in the landscape where the thermal releases and begins to climb. Remember warm air is buoyant and will never go downhill, if the landscape dips, the thermal releases. Loitering slightly downwind of the trigger line is a very good trick for flatland flying. If the place you want to go next has sun and wind, then you are looking at a two star location. Worth a go if there's nowhere else better within reach, but it's still not a dead cert.

Landscape

Neither the sun nor the wind will produce any lift without a landscape to interact with. In the flatlands the landscape's ability to absorb the sun's warmth is crucial to thermal generation. Dark-colored things heat up better than light-colored things.

Wear a black T-shirt on a sunny day for ten minutes and then change in to a white one and you'll immediately feel the difference. A dark area on the landscape, like an area of freshly ploughed fields surrounded by green pastures, will heat up much quicker than the fields around it.

But it's not just color that's important, texture and aspect also play their role too. Bubbles of air move easily over or away from a smooth surface whereas a rough surface, like the stubble in a field of a recently cut crop, can have a Velcro-like effect on the warmed air.

Although it takes longer to heat up it will hold on to the heat longer than a smooth surface, which releases quickly and often, therefore it often produces a hotter bubble of air.

Clouds

A cumulus cloud is just the part of the thermal you can see. If there's a cumulus cloud there, then there's a thermal there, because cumulus clouds are only formed by rising air. This is one of the most difficult rules of XC flying to follow, because often other clues conspire against you and lure you away.

Cu's might be forming in odd places away from where you normally expect to see them or you might come across a cu in the middle of the valley with no apparent reason to be there. It doesn't matter if it's defying all your local knowledge and everything you've ever learnt. It doesn't matter if you haven't the faintest idea what's causing it and why it's there.

Cumulus clouds are only formed by rising air. If there's a cu there, you can climb there. I've often forced myself to turn away from my planned route, or I've dived low into what appears to be a stupid place according to all the other rules, because a cu has started building nearby and shows me where the air is definitely rising.

Equally, I have landed confused as to why the really obvious sunny ridge didn't work only to realize I've ignored an unexplainable line of Cu that was actually in easy reach.

This is the one rule of XC flying that you should follow religiously. Plugging on with your flight plan into a cloudless area on a day where cu is forming elsewhere is folly, and will almost always put you on the ground or get you stuck. If your next destination has sun, wind, a good landscape and a cloud it's a four star choice and you are just about guaranteed a climb.

Birds and Gliders

If you're confronted with a four star location there is only one thing that can possibly give more confirmation of the presence of a thermal and that's the sight of someone or something climbing in it.

Five stars means that the thermal is definitely there and good enough for you to climb in. Only ever ignore a five star location if you can see another high-ranking location within reach further along your course.

The Five Star system is a fairly accurate method of deciding the potential of your next location. However, flying is a very fluid art. The sky is continually changing and developing and a good XC pilot is continually assessing what they see and updating their mental picture of the sky ahead.

Thermal Theory by Will Gadd

A little more thermal theory is useful to understand how to fly them. I believe thermals close to the ground are often quite small and relatively violent. As they rise they tend to smooth out and expand. Pressure also tends to influence thermal formation; high-pressure days tend to produce smaller, sharp-edged, "punchy" thermals. Lower-pressure days can produce very strong thermals obviously, but they tend to have mellower edges and be larger in size.

The day's lapse rate also influences thermal strength; a hot day with a very strong lapse rate will produce stronger thermals. Think of a very warm piece of air rising out of a collector on a day with a strong difference in air temperatures between the ground and say 5,000 feet above it. A thermal will rise quite quickly in this situation. An inversion is the opposite, and not surprisingly thermals usually stop or at least slow down at inversions.

The above factors (and hundreds more but this is a start) give each day its thermal "profile." If you launch on a clear blue day (indicating high pressure) with a good lapse rate (you checked the day's soundings), then you might expect sharp-edged, strong thermals. If, however, the sky is filled with soft cumulus and looks somewhat hazy due to moisture, then you might expect softer thermals. The first thermal of the day provides some good clues about what's happening; if it rips you upward and all you have to do to stay in it all the way to base is turn a bit then you're off to a good start. If it's small and difficult to stay in then ends abruptly 1000 feet later and you can't take it any higher, then you know the day will be more difficult. I take a mental note of three important characteristics with each thermal I use during the day. What is my average climb rate? Not the spikes, but the true climb rate as expressed by a 20-second average? How high do I get before it totally falls apart, and are there any altitudes that seem tricky to keep climbing through? And finally, what are the size and drift of the circles I'm making?

The climb rate tells you what to expect as the day progresses; climb rates tend to improve until late in the day, and thermal size also tends to increase as the day wears on (sink too unfortunately). If you're getting solid 600fpm climbs, then it's probably not worth stopping in 100fpm on a glide unless you're low (anything going up when you're low is great). The peak thermal altitude is also useful; if you are getting to 6,000 feet AGL consistently but a strong thermal suddenly "stops" at 4,000 AGL then you've probably lost it and should search for it. However, if the thermal stops at 5,800 feet then it's most likely done and time to go on glide. Remember that the peak altitude of the thermals should increase as the day progresses. On good days in Texas it's not uncommon to see thermals in the morning only reach 4000 AGL, then 6000 AGL at noon, 10,000 at 2:00 p.m. and 14,000 at 5:00 p.m. This progression is generally less in the mountains but still observable.

Finally, the size and drift of your circles at various altitudes also tells you what to expect on the next climb and information on wind speeds aloft. This tells you what angle your thermal will be flowing from a collector so you can intersect that line I (note-very strong thermals will have no problem pushing the wind around them like a bridge abutment in the river).

Centering: The Mental Map

OK, so your vario is beeping like mad; how long do you wait before turning? If the day's thermals are small and you're low, start turning immediately after you're sure you've hit something (not just a gust). Rules of thumb about waiting two seconds etc. are meaningless in my experience. You've found lift, initiate a smooth banked turn and see what happens. If you climb really well for a quarter circle and then start sinking, open your circle up a little bit in the direction you found the best lift then tighten as the lift increases; notice the pressure in your wing and how your butt feels in the seat, not just the vario beeping, these are critical clues. Listen to the noise in your ears as well; with practice, you can actually hear the different air flows as you fly through lift or sink; if you can't hear the air then get a new helmet. At some point in your circle everything will add up to the best lift as defined by your vario, wing pressure and lift under your butt. If you're flying a coordinated 360 then it's relatively easy to develop a mental map of where the best lift is in each 360; don't worry about the ground, but where you encounter the best lift within each circle. Try to develop a "mental map" of what's happening in each 360.

To fly toward better lift, maintain a coordinated turn, just reduce the bank slightly as you come back around the 360 and move the center of your circle over a little bit toward where you got the best lift. NEVER STOP CIRCLING. Once in the best lift, tighten the circle up slightly while maintaining a coordinated turn. Perhaps you get solid lift for half the turn, general sink for half the turn. Move the circle in the direction of the best lift again. Now you get solid lift for three quarters of the turn and less lift for one quarter. Move it again. Now you're climbing solidly for the full revolution of your turn at +400 fpm average, but one portion of your circle is going up at +600 and another at only +200. If you weren't in a coordinated turn, and most pilots aren't, this would probably be due to the oscillations inherent in thermalling in an uncoordinated turn and you would not have a clue what's actually going on. But you know to thermal in a coordinated manner, so you move your circle toward the +600 and eventually lock in a perfect 1000fpm climb all the way to base. Irregular thermals may give irregular "instantaneous" readings on your vario, so focus on getting the best average climb rate that you can. Hang gliders and sailplanes can use all kinds of funky ovals and figure-eights to get better average climbs, but I have found paragliders climb best flying coordinated, continuously adjusted circles (or straight if the thermal is big enough!).

Circle Size and Bank Angle

I find I thermal with 30-45 or more degrees of bank on days with small, strong thermals, 15 to 30 on lower pressure days and almost flat on days with light, wide thermals. The extremes of bank angles come in dust devils (almost vertical) versus flying straight and flat while climbing like mad under a big cloud; somewhere between these two extremes is the correct angle for your thermal on that day. Every glider responds differently to brake force and the amount of lean; what works for one pilot on his glider usually has little to nothing to do with yours. However, every glider will circle in a coordinated manner, and the feeling is unmistakable once you get it.

Here are a few scenarios to help pick bank angles for thermalling. Say you're flying along in -600 fpm and suddenly you're screaming up at +800. You turn, then go down at -400,so you move your circle toward the +800 but can't lock it in despite continually re-centering your circle. You probably need a higher bank angle and smaller circle. If you're very low in a small thermal, you may only be able to get half a turn in. Do your best to just improve how much of each circle you spend in lift, you'll lock it eventually as you climb. Another scenario: you're flying along in -600 when your sink rate starts to decrease smoothly to zero sink, then +200, then +300. I would keep flying straight until the lift starts to decrease, then initiate a relatively gentle bank and center on the best average climb rate. A relatively gradual, consistent rise in your climb rate is a sign of a large thermal. Often you can find very strong cores in large thermals that will offer much higher rates of climb, but in general the larger the thermal, the less bank angle the better to maximize your climb rate. Some bank angle is usually good; a glider won't turn in a coordinated circle without it, but you can fly in a coordinated turn with equal brake using lean; watch a good pilot fly and you can tell he or she is often controlling the glider primarily with lean and modest adjustments to the outside brake.

There is no correct number of pounds to pull on your brakes while thermalling or distance to pull them down (1/4 brake is meaningless across a range of gliders), but there is a correct amount of brake to pull and lean to maintain a coordinated turn. It's like riding a bike; no one can tell you how to do it, but you stay upright when it works. I generally thermal with roughly twice the amount of brake pressure on the inside brake than the outside, and adjust my turn primarily with lean and the outside brake. You will probably do it differently, but know a good coordinated turn when you hit one.

Don't change directions when thermalling, especially when low. There are three good reasons for this; First, changing directions messes your coordinated turn up and you have to fly straight for some time between turns which usually takes you away from the lift (all directions but one lead away from the lift). Second, you lose your mental "map" of where the best part of your circle was. Third, the direction change will cause your vario to beep in all kinds of interesting but non-helpful ways. It is almost always better to simply move your circle over toward the better lift than try to switch directions and fly toward it.

If you're having a hard time maintaining a coordinated turn, try flying a bit faster; use more lean and less inside and outside brake. Many pilots try to fly a perfectly flat circle; in truly massive lift this works well, and your glider may have its best sink rate with a fair amount of brake on. However, I find flying a bit faster with a mild bank often enables me to lock in the thermal's best lift. Don't confuse what works well while ridge soaring with what works best thermalling, it's a very different game.

What To Do When You Lose the Lift

First, know if you're at the top of the thermal or not. If every thermal so far has ended at 6,000 AGL and you're at 5,700 then forget about it and go on glide. But if you're climbing well at 3,000 AGL and lose the thermal then it's time to go into search mode. If there's any wind at all, the thermal is probably either directly down or upwind of you. The first thing to do is expand the size of your circle and pay attention to your mental map. If you were climbing at +200 fpm and then start sinking at -600 on the upwind portion of the 360, open the circle up back downwind. If the sink improves to -400 and then -200, move it even more downwind. If nothing good happens, try moving upwind; again, an improvement in sink is as as relevant as finding more lift, work toward the area of lesser sink. Also pay attention to your groundspeed; it will generally increase as you follow the air flowing into a thermal, but decrease if you're bucking the wind flowing into a thermal by flying away from it (remember that thermals, especially when low, pull or entrain air into them). If I'm low on windy days I tend to fall out the upwind edge of the thermal. If I'm high on a windy day I tend to fall out the downwind edge of the thermal. I have no idea why, but that's how it works.

I've seldom encountered thermals that are smooth cylinders from the ground to base; the trick is to follow your vario, wing and seat pressure up in the best lift with continual gentle adjustments to your coordinated circle.

More Clues for Better Thermalling

If the outside of your wing loses pressure suddenly and ruffles or takes a mild collapse, you've just found a relative difference in lift. Perhaps you're in +600 and your outside wing just hit some +50; you want to move your circle away from the area you just took the turbulence in and toward the better lift. If you're thermalling in a gaggle and see someone, take an outside wing deflation ahead of you in the circle, then it's probably worth tightening your circle away from that area and then opening it slightly to fly toward the better lift, tightening the circle as you encounter better lift. Most pilots tend to fly the "pattern" in a thermal rather than really watching the climb rates of the other gliders; if everyone climbs better in one half of their circle than the other, move your circle toward the better lift; you'll climb above the other gliders quite quickly using this tactic. If someone is out-climbing you off to one side then move your circle to them; there's no heroism in climbing slowly by yourself.

If you see the glider in front of you in a gaggle start climbing like mad, you may want to start tightening your circle immediately so you are in a higher bank angle as you hit the rising air and can "grab" more of it; again, fly the thermal, not the other pilots.

Look for pollen, plastic bags, bugs and other debris in your thermal. Birds in general and Swifts will almost always be in the best part of a thermal; follow them immediately. Swifts and other small birds seem to eat the bugs that are drawn into thermals; if you see a group of them swarming upward, jump in with them even if doing so requires a short glide. Because thermals are pulling air into them, trash often automatically centers itself in a thermal; I've climbed thousands of feet in the company of newspapers or other debris.

Some days produce thermals that seem to want to spit you out; most of the time I've found that this is due to flying with too large a circle. Think of a spout of water shooting upward; if you stick your wing into the center and keep your circle within the column, you'll go up. But find the edge and you'll lose pressure on the outside of your wing. This creates drag, you lose your bank angle and tend to get "pulled" out to the side.