Glossary

for use with

Getting Started with Drones and Model Airplanes

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14 CFR Part 107. That portion of Title 14 of the Code of Federal Regulations, also known as the Federal Aviation Regulations (FARs), that pertains to small uncrewed aircraft systems (sUAS) flown for non-recreational purposes—Part 107. It is the default ruleset for all drone operations in the United States and is applied to would-be recreational pilots who have not met all the qualifications to operate under 49 USC §44809.

49 USC §44809. Title 49 of the United States Code, Section 44809 outlines the requirements for a remote pilot to operate a drone or model airplane under the recreational rules, rather than 14 CFR Part 107. These include completing The Recreational UAS Safety Test (TRUST), registering their aircraft on the FAA DroneZone, and abiding by the safety code of a nationally recognized Community-Based Organization (CBO).

above ground level (AGL). The altitude of an aircraft above the terrain, as opposed to its altitude above mean sea level (MSL). In drone operations and the rules that govern them, altitude above ground level (AGL) is referenced most often. On the other hand, crewed aviators typically refer to their altitude MSL, which is displayed on standard aircraft altimeters. This distinction is critical because if you're flying 9,000 feet MSL at Pikes Peak, Colorado, your aircraft is a mile underground. *See* mean sea level.

Academy of Model Aeronautics (AMA). A private, nonprofit organization established in 1937 and based in Muncie, Indiana, that serves as the governing body for aeromodelling activities in the United States. It is led by a board of directors elected from 11 regional districts, as well as a president elected by the membership at large. Recognized by the FAA as a Community-Based Organization (CBO), the AMA promulgates a safety code for recreational small uncrewed aircraft systems (sUAS) operations and offers a wide range of benefits to its members, including a monthly magazine and $2.5 million in liability insurance. If you're not already a member, read that last part again—and then become one.

accelerometer. An electronic gizmo that measures how quickly an object—such as a drone or model airplane—is accelerating in one of its axes (plural of "axis") of rotation. The force created by this movement squeezes a piezoelectric material that produces an electrical charge in proportion to that force. This result can be measured and used to provide input to an aircraft's flight control system (FCS) to optimize its performance.

actuate. A fancy word for "move," as in: "I actuated the pedals on my bicycle to set its wheels in motion and speed my way home."

aerodynamic stall. A condition that develops when the flow of air over the upper surface of an airfoil is no longer sufficient to maintain lift, either because the airfoil is traveling too slowly or has exceeded its critical angle of attack. In the case of a fixed-wing airplane under normal circumstances, this results in the aircraft executing an uncontrolled nose-down pitch maneuver, thereby regaining speed, which causes the wing to resume generating lift (provided said aircraft doesn't hit the ground first).

aerodynamics. A specific application of the physical sciences that studies the interaction between air and physical objects moving through it. Aerodynamics is not only relevant to flying machines, but also sailing ships, automobiles, and wind turbines, among countless other examples. Have you ever seen a Formula One car? That thing that sticks up on the back is an airfoil, except that it's mounted upside-down so that it creates down-pressure to keep the car from literally flying off the track at high speed.

aeronaut. The old-timey and yet still extremely cool title traditionally given to the pilot of a balloon, blimp, or dirigible.

aileron roll. An aerobatic maneuver performed by fixed-wing aircraft during which it rotates through a full 360 degrees about its roll axis. I'll let you guess which control surfaces are actuated to make that happen.

ailerons. A pair of control surfaces mounted outboard on the trailing edge of an airplane's wings that move in the opposite direction from one another. They are nominally responsible for maneuvering the aircraft in its roll axis.

air gap. In a brushless electric motor, the air gap is the tiny space between the rotor and the stator. The existence of the air gap is

a crucial distinction between brushed and brushless motors: because these components are not in direct physical contact with one another friction and wear are both substantially reduced.

airspeed indicator (ASI). In crewed aviation, the airspeed indicator (ASI) is an instrument that displays the speed of the aircraft through the air, typically measured in knots. As part of the pitot-static system, the ASI is capable of functioning without external power.

air traffic control (ATC). Short version: They who must be obeyed. Slightly longer version: Air traffic control (ATC) is a part of the national airspace system (NAS), responsible for the safe and efficient movement of aircraft through the volume of air from the tops of our heads to the edge of the atmosphere. While the airport control tower is the most widely recognized manifestation of ATC, it also includes regional centers and even automated systems like the Low-Altitude Authorization and Notification Capability (LAANC).

airfoil. A specific shape that exploits the Bernoulli Principle to generate lift: one of the four forces of flight. Seen in airplane wings and propeller blades, the airfoil in its most basic form is curved across its upper surface and flat on the bottom. This causes a pressure differential in the air moving past it, which creates lift.

ALC-677. An Aviation Learning Center (ALC) course offered online by the FAA Safety Team (FAAST) to satisfy the recurrency requirements for commercial remote pilots certified under 14 CFR Part 107. To keep their certificates "current"(meaning valid), professional drone operators must complete recurrent training once every two years. ALC-677 is the easiest and least expensive option (read: free) for accomplishing this task.

altitude sickness. Ironically, given the fact that this is a book all about aviation, altitude sickness is not something that is typically experienced by crewed aviators. Rather, it can affect people who venture high into the mountains, potentially because they want to use a drone to capture some cool aerial video of glaciers and alpine peaks. The reduced level of oxygen at higher elevations is the cause of altitude sickness. Symptoms can include headache, vomiting, insomnia and reduced mental acuity and physical coordination. Because many of these are associated with the safe operation of aircraft, remote pilots should monitor themselves for signs of altitude sickness when flying at elevation.

angle of attack. The angle of attack, despite its aggressive-sounding name, is simply defined as the angle at which the leading edge of an airfoil (or, more specifically, that airfoil's chord line) meets the oncoming air. As the angle of attack increases, so does the lift generated by the airfoil—right up to the moment it crosses the critical angle of attack, at which point the smooth flow of air over its upper surface collapses. This results in a sudden and dramatic loss of lift known as an aerodynamic stall. *See* cord line.

antitorque rotor. The antitorque rotor—(sometimes referred to by the unschooled as the "tail rotor"—)is the little propeller mounted on a boom at the back of a conventional helicopter that rotates on a geometric plane perpendicular to the ground. It serves two basic functions: it counteracts the torque reaction created by the rotation of the main propeller on top of the helicopter and allows the pilot to control the aircraft's maneuvering in the yaw axis.

aperture. Aperture is just a fancy word for "hole." In photography, it specifically refers to the opening that allows light to pass through the lens and fall upon the sensor—or, if you're an old-school shutterbug, the film—responsible for capturing the image. The size of this whole is measured in f-stops, with small numbers (e.g., f/2) corresponding to a large hole and large numbers (e.g., f/32) corresponding to a small hole, because nothing is ever easy.

armed. "Armed" describes a system that is ready to be put into immediate action. In remote piloting, many drones must be armed before they begin responding to control inputs. This is a safety feature to ensure that the pilot does not accidentally start the propellers turning before they are ready—potentially causing injury or damage.

arresting gear. While virtually unknown in small, civilian drone and model airplane operations, arresting gear refers to a system that captures an aircraft and immediately terminates its flight. These are typically used when the aircraft is incapable of landing

safely on the ground and must therefore be caught in midair, or when it is necessary to stop the aircraft in a short distance, such as when high-performance jets land on an aircraft carrier. No surprise, systems and spaces that require arresting gear often also require the use of launch catapults. *See* launch catapults.

artificial intelligence (AI). A computer system that mimics the thinking process of the human mind, which can be applied to a variety of tasks, such as: writing, creating, and editing images and world domination. I, for one, welcome our robot overlords.

Association for Uncrewed Vehicle Systems International (AUVSI). The world's largest trade association dedicated to uncrewed systems across all domains, such as robotic boats and submersibles, terrestrial rovers, and self-driving cars, as well as drones—although aerial systems represent the largest segment of its membership. The organization has more than 35 local chapters worldwide and each year hosts the industry's largest trade show, XPONENTIAL. It also sponsored the development of the Trusted Operator Program (TOP), to certify commercial drone pilots to a standard of knowledge and performance beyond the relatively low bar established by 14 CFR Part 107.

attitude. In aviation, the word attitude describes the relationship between a part of an aircraft in flight and the horizon, such as a nose-high or nose-low attitude. If a more experienced pilot tells you to "watch your attitude" while you are flying, they are most likely not criticizing your surly disposition, but rather trying to help you avoid a crash.

automatic white balance (AWB). A system within modern digital cameras that seeks to automatically compensate for the different color temperatures of light that might fall across a scene: whether it is the cold blue glow of a fluorescent tube, or the warm orange light of a campfire.

bands. A radio band is a specific range of frequencies, defined by the Federal Communications Commission (FCC), that is used for the same purpose: such as commercial broadcasts or wireless digital communications. Radio transmissions must be regulated because if two signals are sent simultaneously on the same frequency, both will become unintelligible.

banked turn. A banked turn results when a fixed-wing aircraft maneuvers in its roll axis, thereby causing a portion of the lift developed by its wings to act laterally in the direction of the roll. The most immediate effect of this is a change in the aircraft's yaw—the "turn" in a "banked turn."

barometric altimeter. An instrument used in both crewed and uncrewed aviation that measures the altitude of an aircraft by determining the density of the surrounding air, exploiting the fact that as altitude increases, air density decreases. In crewed aviation, the altimeter is part of the pitot-static system and is calibrated to display the aircraft's altitude above mean sea level (MSL). On board drones, the altimeter relies on a piezoelectric sensor and displays the aircraft's elevation above its launch point, generally reflecting its altitude above ground level (AGL).

BeiDou Navigation Satellite System (China). A constellation of global navigation satellite system (GNSS) satellites put into orbit and maintained by the People's Republic of China. Accessible worldwide, the system incorporates 30 active satellites, the first of which was launched in the year 2000. The Chinese name "BeiDou" refers to the star constellation known in the United States as the Big Dipper.

bell housing. In an outrunner-configured brushless electric motor, the bell housing comprises the rotor: that is, the part of the motor which rotates. When removed from the stator, which comprises the motor's core, it somewhat resembles a bell—thus the name. It does not, however, ring.

belly landing. When an aircraft without an undercarriage lands on its underside, it is referred to as a belly landing. This is a not-uncommon configuration for model airplanes. Belly landings can also occur in crewed aviation as an emergency procedure, when an aircraft suffers a mechanical failure that makes it unable to extend its retractable undercarriage prior to landing.

Bernoulli Principle. A foundational concept in the field of fluid dynamics, the Bernoulli Principle states that when the speed of

a fluid—to include the air in Earth's atmosphere—increases, the pressure exerted by said fluid on its surroundings decreases. The shape of a conventional airfoil is designed to exploit the Bernoulli Principle to generate lift.

Biennial Flight Review (BFR). To maintain the currency of their certificates, crewed aviators are required to complete a Biennial Flight Review (BFR) once every two years—which won't come as a terrible shock if you know what the word "biennial" means. This requires the pilot to receive a minimum of one hour of ground instruction and one hour of flight instruction from a certified flight instructor (CFI), which must be noted in the pilot's logbook. In an analogous manner, commercial drone pilots operating under 14 CFR Part 107 are required to complete ALC-677 once every two years to maintain currency.

binding. In remote piloting, binding is the process of connecting an aircraft to the hand-held controller that the pilot will use to direct its maneuvers in flight. The procedure is similar to pairing a Bluetooth accessory to a smartphone.

biplane. A multi-wing airplane with two wings, like the original Wright Flyer and most aircraft that saw action during World War I. The principal advantage of the biplane to the designers of those early aircraft was that it allowed for the same total wing surface area with less structural support—a critical factor when wings were made of canvas and wood.

brushed motor. An electric motor that functions with several of its working components—the brushes and the commutator—in direct, physical contact with one another. This results in friction and the buildup of heat inside the motor, making it less efficient than a brushless electric motor. Also, these parts wear down over time, meaning that brushed electric motors must be periodically overhauled or replaced.

brushes. Inside a brushed electric motor, the brushes—which don't actually resemble the brush you use on your teeth, or anything else, for that matter—transmit electrical power to the commutator, which changes the magnetic polarity of the armature. This serves the same basic function as the electromagnets inside a brushless electric motor. While we're on the subject, don't forget to brush your teeth. Good oral hygiene is its own reward.

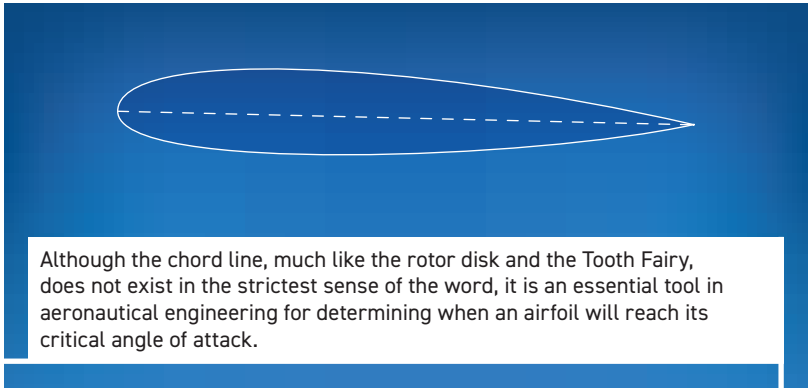
brushless motor. Inside a brushless electric motor, an air gap separates the rotor from stator, meaning these two components never come into direct, physical contact—unless something goes horribly, horribly wrong. As a result, brushless electric motors are far more efficient than their brushed counterparts and can operate for years with minimal maintenance.

center of gravity (CG). In physics and engineering, the center of gravity (CG) is an imaginary point associated with an object where, for purposes of analysis, the total weight of that object can be assumed to be concentrated. Alternatively, the CG is the point around which the object will rotate in freefall, as in zero gravity. Managing the location of the CG is critical for the safe operation of aircraft. If the CG moves beyond a range defined by the aircraft's designers, the aircraft can become unpredictable or even uncontrollable in flight.

center of pressure (CP). Just as the weight of an aircraft can be said to act at its center of gravity (CG), the total lift generated by that same aircraft's wings can be said to act at its center of pressure (CP). The relationship between the CG and CP is crucial in determining the stability of the aircraft. Fortunately, establishing the CP in the correct position is pretty much the exclusive concern of the aeronautical engineers who design aircraft—not the pilots who fly them.

checkride. In crewed aviation, before a pilot earns a certificate, they must demonstrate their proficiency to a Designated Pilot Examiner (DPE), in much the same way that a new driver must complete a test with a representative of the department of motor vehicles along for the ride. Note: there is no parallel parking requirement. The check ride is conspicuously absent for pilot certification under 14 CFR Part 107, which creates the possibility of a certified pilot with no skill whatsoever in operating the aircraft. In an effort to eliminate this (seemingly obvious) shortcoming, the AUVSI Trusted Operator Program (TOP) incorporates a check ride at its higher levels of certification.

chord line. An imaginary line that connects the leading edge of an airfoil to its trailing edge. Do not cut open the wing of your airplane looking for the chord line—you won't find it. It's imaginary, remember? The reason the chord line is important is that a wing's angle of attack is measured from its chord line, not any physical feature of the wing itself.



Although the chord line, much like the rotor disk and the Tooth Fairy, does not exist in the strictest sense of the word, it is an essential tool in aeronautical engineering for determining when an airfoil will reach its critical angle of attack.

coaxial helicopter. A rotorcraft that incorporates two counter-rotating propellers on a single shaft. The type is perhaps most familiar to the general public because of Ingenuity, the Mars helicopter, which arrived on the red planet in 2021 along with the Perseverance rover. Coaxial helicopters are both more stable and more compact than other types of rotorcraft.

collective input. In the control schema of a conventional helicopter, increasing collective input increases the pitch of the main propeller's rotor blades across the entire rotor disk, causing them to generate more lift. Under nominal circumstances, this will cause the aircraft to ascend. Reducing collective input will cause it to descend.

collision avoidance system. Short version: A system for avoiding collisions. Slightly longer version: Many small drones incorporate systems, most often relying on a pair of cameras that function like human eyes to build a 3D model of the surrounding environment. This system alerts the pilot to the presence of nearby obstacles or even overrides pilot input to prevent an imminent collision.

color temperature. Measured in degrees Kelvin—but not the same degrees Kelvin used to reckon absolute zero—color temperature is used to identify the hue of light falling on a scene, whether delivered by natural or artificial light sources. These range from "warmer," more reddish light, emitted by candles and the setting sun, to "colder," more bluish light, emitted by fluorescent tubes or the midday sun. Assessing and accounting for color temperature by means of white balance is a necessary step in photography, so that the colors in the captured images reflect those in the real world.

Common Traffic Advisory Frequency (CTAF). At small airports that lack a control tower, crewed aviators coordinate among themselves in order to ensure separation and avoid airspace conflicts. This is accomplished by means of a Common Traffic Advisory Frequency (CTAF), over which all pilots operating in the vicinity will broadcast their locations and intentions. A wily drone pilot, having taken the time to understand aircraft communications protocols, can listen in on an airport's CTAF frequency to enhance their situational awareness (SA).

community-based organization (CBO). A designation mandated by Congress and implemented by the Federal Aviation Administration (FAA), a community-based organization (CBO) is a private, nonprofit group that publishes a safety code for recreational small uncrewed aircraft systems (sUAS) operations and oversees their operations by its members. The oldest and most well-established CBO is the Academy of Model Aeronautics, founded in 1936.

commutator. A component of a brushed electric motor responsible for alternating the polarity of the armature, a rotating electromagnet inside the motor that generates torque when electrical current is applied. In order to function, the commutator must be in direct, physical contact with the brushes, resulting in friction and the buildup of heat—making them less efficient than brushless electric motors.

constellation. In the context of global navigation satellite systems (GNSS), a constellation is a collection of satellites that operate using a common set of radio frequencies and communications protocols, allowing users with appropriate receivers on the Earth's

surface to determine their location with a high degree of precision. Multiple nations maintain their own global GNSS constellations with worldwide accessibility, including: the United States, China, the European Union, and Russia.

control horn. A lever arm attached to a control surface on a model airplane, which allows a servo to actuate the surface by means of a push rod. Note: Control horns do not honk.

control line (CL) flying. A type of aeromodelling activity entirely separate from conventional, radio-controlled flight. In control line flying, the pilot is tethered to the aircraft by—you guessed it—control lines. By manipulating these lines, the pilot can actuate control surfaces on the model, allowing it to perform aerobatic maneuvers.

control surfaces. Control surfaces are moveable panels that are generally located on the trailing edges of an airplane's wings and stabilizers. The most common among these are the elevator, the ailerons, and the rudder—which nominally allow the pilot to control the aircraft's pitch, roll, and yaw, respectively.

controlled airspace. Controlled airspace is that portion of the nation's airspace that requires approval from an air traffic control (ATC) authority before any aircraft is allowed to enter and operate within it. The largest body of airspace—designated "Class A"—exists over the entire surface area of the United States between the altitudes of 18,000 and 60,000 feet above mean sea level (MSL). Of much greater interest to drone and model airplane pilots are Class B, C, D and E airspace, which surround larger airports. UAS operators can obtain permission to operate in these areas either through the Low-Altitude Authorization and Notification Capability (LAANC) or by seeking an authorization or waiver from the FAA Drone Zone.

coordinated turn. In fixed-wing flight, a coordinated turn is a maneuver that relies on simultaneous control inputs to the aircraft's ailerons, elevators, and rudder, such that the load resulting from the turn is maintained in perfect balance.

cyclic input. In the control schema of a conventional helicopter, increasing cyclic input increases the pitch of the main propeller's rotor blades across a portion of the rotor disk. The result is the asymmetric production of lift, which causes the aircraft to pitch or roll in the opposite direction to maneuver the aircraft.

deconflict. Deconfliction describes any process or procedure that seeks to avoid potential conflicts among participants operating in the same space at the same time or relying upon a common resource, such as radio frequencies. For example, early aeromodelling enthusiasts used controllers that employed discrete, fixed frequencies. If two pilots transmitted on the same frequency at the same time, the aircraft would receive simultaneous—and contradictory—control inputs, likely resulting in a crash. To prevent this, each flying field had a board with tags corresponding to each available frequency. Before powering up, a pilot would claim the tag corresponding to their frequency, and no other pilot using a controller tuned to that same frequency was allowed turn on their system until the tag was returned to the board. Today, first-person view (FPV) pilots using analog video transmitters must rely on similar procedures.

depth of field. In photography, the depth of field is that distance between the camera's lens and infinity where objects that appear in the frame will be in focus. The depth of field can be quite broad—stretching literally for miles—or very narrow, being limited to a fraction of an inch.

dihedral angle. In fixed-wing aviation, the dihedral angle reflects the degree to which the wing of an airplane slopes up from the point where the wing is attached to its fuselage. The steeper this angle, the greater the intrinsic aerodynamic stability of the aircraft.

drag. One of the four fundamental forces of flight, drag is created by the friction of the aircraft's body moving through the air. Drag acts in opposition to thrust.

drone racing. Also called "FPV racing," drone racing is a competitive activity that involves remote pilots operating highly specialized aircraft—typically quadcopters measuring just a few inches across—at speeds that can approach 100 miles per hour. They steer these through an obstacle course while wearing video goggles that

allow them to see from the aircraft's perspective (i.e., a "first-person view" or "FPV"). Frequent crashes are a routine part of drone racing, so you should anticipate your aircraft repair skills will grow alongside your piloting skills.

dynamic soaring. A specialized aeromodelling activity that involves high-performance gliders soaring over steep mountain peaks and escarpments that create extremely fast localized winds. By harnessing these winds, the pilot is able to achieve speeds in excess of 500 miles per hour—the fastest speeds ever recorded for a model airplane.

electric-ducted fan (EDF). An electric-ducted fan (EDF) is a small-diameter, high-speed propeller contained within a tube open at both ends and enclosed within the body of a fixed-wing model airplane. While inefficient compared with a conventional, external propeller, an EDF can be used to re-create the appearance of a jet-powered aircraft without the danger or expense of employing an actual jet turbine. Most EDF aircraft emit a distinctive, high-pitched whine that may make them unwelcome in some public venues.

electric motor. A device that transforms electrical current into torque, which can be used to do work—such as drilling holes or scrambling eggs. On board drones and model aircraft, electric motors are used to turn propellers, generating the lift or thrust required for flight.

electromagnet. Essentially, an electromagnet is a magnet with an "on-off" switch. When electrical current is flowing, an electromagnet generates a magnetic field. However, when the current is cut off, it becomes magnetically inert. In outrunner-configured brushless electric motors, a series of electromagnets comprise the stator.

electromagnetic interference (EMI). A type of interference that affects radio transmissions, like the ones used to control drones and model airplanes, originating from a source that generates radio waves as a byproduct of its primary function—such as an electrical substation or high-tension powerlines.

electromagnetic spectrum. The electromagnetic spectrum encompasses all of the wavelengths in the universe that are capable of transmitting energy, from the Gamma Rays generated by exploding supernovas to the Extremely Low Frequency (ELF) radio waves that can comfortably fit Earth's moon between their peaks. The electromagnetic spectrum also includes visible light, which the human eye uses to perceive the physical world, as well as the frequencies used for radio transmissions, microwave ovens and medical X-Rays, among others.

electronic speed controller (ESC). An electronic device used to power and control the rate of rotation of a brushless electric motor. Each motor requires a dedicated electronic speed controller (ESC) to function. Thus, the number of ESCs on a drone or model aircraft will always equal the number of motors it carries.

elevators. In fixed-wing flight, the elevators are control surfaces that are typically attached to the trailing edge of the horizontal stabilizer and are actuated by the pilot to affect the airplane's attitude in the pitch axis.

Embry-Riddle Aeronautical University (ERAU). Established in 1926 as a flying school in Miami, Florida, Embry-Riddle Aeronautical University (ERAU) is today the world's pre-eminent institution of higher learning focused on aviation and aeronautics. The university has residential campuses in Daytona Beach, Florida, Prescott, Arizona, and Singapore, as well as a robust online program known as the Worldwide Campus. On a personal note, I happen to work at ERAU, so the next time you see them, be sure to say nice things about me.

energy density. A measure of the energy available from any source, accounting for its mass and volume, in addition to the stored power it can deliver. Electrically powered flight requires batteries that offer high energy density when compared with those used for other applications, making Lithium-Polymer (LiPo) batteries the only realistic alternative, in spite of their potential volatility.

envelope. The envelope is a component of lighter-than-air vehicles. It contains a gas that is less dense than the surrounding

atmosphere—such as hot air, hydrogen, or helium—to provide the buoyancy necessary to off-set the weight of the aircraft and its crew, thus enabling flight. The envelope can either be flexible—as in balloons and blimps—or rigid, as in dirigibles.

FAA Airman Knowledge Test (AKT). An Airman Knowledge Test (AKT) is a written test administered using a computer system at a testing center approved by the Federal Aviation Administration (FAA). Earning virtually any FAA certificate will entail successful completion of an AKT, including Remote Pilot, Private Pilot, Commercial Pilot, Airline Transport Pilot, as well as Airframe and Powerplant mechanics, Parachute Riggers and Aircraft Dispatchers, among many others. Testing centers are typically located at flight schools at general aviation airports. If you're looking to pass one, my esteemed publisher—Aviation Supplies & Academics (ASA)—provides a wealth of books and online resources to help you prepare. You can even see me in the online Remote Pilot video course!

FAA DroneZone. The Federal Aviation Administration (FAA) DroneZone is a website that provides services, such as aircraft registration, to both commercial and recreational remote pilots. Users are required to create an account with an e-mail address and password to access the system.

FAA-Recognized Identification Areas (FRIAs). A defined geographic space within which drones and model aircraft are allowed to operate without a functioning Remote Identification (RID) system. Such sites must be affiliated either with a recognized Community-Based Organization (CBO) or with an educational institution, such as a primary school, secondary school, trade school, college, or university. The CBO or educational institution must apply to the Federal Aviation Administration (FAA) to establish an FAA-Recognized Identification Area (FRIA), and its authorization must be renewed every four years.

FAA Safety Team (FAAST). A volunteer organization sponsored by the Federal Aviation Administration (FAA) that relies on its members to provide counseling and education to their fellow pilots with the goal of improving safety. Professional remote pilots who serve as members of the FAA Safety Team (FAAST) are known as "DronePros."

Federal Aviation Administration (FAA). An agency of the Department of Transportation (DOT) established in 1958, the Federal Aviation Administration (FAA) is responsible for the safety of the National Airspace System (NAS). Based in Washington, D.C., the FAA employs about 45,000 people, including those assigned to approximately 80 regional Flight Standards District Offices (FSDOs) across the United States. It promulgates the Federal Aviation Regulations (FARs), establishes training and certification standards for pilots, aircraft maintainers and other aviation professionals, as well as publishing sectional charts, chart supplements and other informational materials.

Federal Aviation Regulations (FARs). Also identified as Title 14 of the Code of Federal Regulations (14 CFR), the Federal Aviation Regulations (FARs) are promulgated by the Federal Aviation Administration (FAA) to ensure the safety of the National Airspace System (NAS). Title 14 is divided into several parts, each pertaining to a specific type of aeronautical activity. Part 45, for example, pertains to aircraft registration and identification markings. Part 61 regulates the certification of pilots, flight instructors and ground instructors. Part 73 defines special use airspace and, of course, Part 107 includes the rules that govern the use of small uncrewed aircraft systems (sUAS) for commercial operations. If all of this sounds like exciting reading, please seek immediate treatment from a mental health professional. If, on the other hand, this sounds like an ideal cure for insomnia, then I have some good news: the publisher of this humble tome, Aviation Supplies & Academics (ASA), also publishes an updated version of the FARs annually, in combination with the Aeronautical Information Manual (AIM).

Federal Communications Commission (FCC). An independent agency of the United States federal government established in 1934, the Federal Communications Commission (FCC) has a wide mandate, which ranges from making sure we don't see boobs or hear dirty words on television to the critical task of spectrum allocation. Since each radio frequency can only carry one signal at a time, and the total number of radio frequencies is finite owing to the practical limits of radio technology and the electromagnetic spectrum itself,

signals must be limited to specific, defined bands to protect against interference. The FCC determines and regulates these limits.

first-person view (FPV). Rather than maintain a direct visual line of sight with their aircraft, remote pilots who fly first-person view (FPV) wear a set of video goggles that provide them with a real-time video feed from an on-board camera. This creates an immersive experience that can be likened to sitting on the flight deck of a crewed aircraft. However, because the pilot is not able to see their aircraft directly, both commercial and recreational rules require that a visual observer (VO) be employed to keep the aircraft, and the surrounding airspace, in sight for the duration of the flight.

fixed undercarriage. A fixed undercarriage (a.k.a., the "landing gear") always remains in place beneath an aircraft, even while it is in flight, resulting in increased drag, but also allows for greater mechanical simplicity and reliability.

fixed-wing aircraft. One of four major types of heavier-than-air flying machines—along with rotorcraft, VTOLs and ornithopters—the fixed-wing aircraft is exemplified by the conventional airplane.

flaps. A control surface located on the trailing edge of an airplane's wings, inboard from the ailerons. Unlike the ailerons, flaps move symmetrically and are employed to increase lift, reducing the speed at which a fixed-wing aircraft will experience an aerodynamic stall. They can be used to decrease the length of the aircraft's takeoff and landing roll.

flare. The flare is a maneuver that immediately precedes the landing of a fixed-wing aircraft. The moment before the undercarriage contacts the ground, the pilot applies slight back pressure to the elevators, pitching the nose upward and bleeding off airspeed, such that the aircraft experiences an aerodynamic stall at the precise instant it touches down. Nobody—and I mean ***nobody***—can pull this off correctly every single time.

flight control system (FCS). A computer on board a drone or model aircraft that uses data gleaned from various sensors, such as gyroscopes and accelerometers, among others, to enhance the stability of the aircraft in flight.

flight line. Within the Academy of Model Aeronautics (AMA) safety code, the flight line is a boundary that separates soft, fleshy humans from the fast-turning propellers of their radio-controlled flying machines. The goal is to ensure that people and aircraft under power never occupy the same space at the same time, which should—theoretically, at least—preclude the possibility of injuries.

flight management system (FMS). A flight management system (FMS) is notionally the same thing as a flight control system (FCS): a computer that takes input from a variety of sensors to enhance the stability of an aircraft in flight. However, the term is generally applied to this type of system installed on crewed aircraft which, as you would expect, are far more sophisticated and robust than the one you might find on a $99 model airplane.

floatplane. A fixed-wing airplane equipped with floats, or pontoons, allowing it to safely take off and land on water.

floats. Floats are pontoons, mounted on an aircraft in place of a conventional, wheeled undercarriage, which allow it to safely operate on water.

fly-by-wire. A method for controlling a crewed aircraft that relies on a flight management system (FMS) to interpret the pilot's control inputs and actuate its control surfaces and throttle to ensure the safety and stability of flight. The alternative to a fly-by-wire system is for the pilot to exercise direct, manual control over these functions by means of mechanical or hydraulic control linkages.

flying boat. A flying boat is a fixed-wing airplane that makes belly landings on water as a part of its nominal operations. Unlike a floatplane, which relies on pontoons for floatation, the hull of a flying boat is itself the primary source of buoyancy.

four forces of flight. The four forces of flight are fundamental to an understanding of how heavier-than-air flying machines operate. They are thrust, lift, drag and weight.

frame. In photography, the frame is defined by the edges of the camera's viewfinder. It represents the borders of the image that will be captured by its sensor or, if you're an old-school photographer, on film.

free flight (FF). A specialized aeromodelling activity that is entirely separate from radio-controlled flight. Free flight is much like making and launching a paper airplane, if your paper airplane was a meticulously crafted exemplar of aerodynamic perfection. Aircraft are launched either by hand or using a slingshot. These models can be unpowered, powered by wound rubber bands, or by electric motors or gasoline engines designed to shut down after providing a few seconds of thrust. As a competitive activity, the plane that stays aloft the longest wins—but the real winners are the people who build them and thereby gain a deep understanding of aerodynamics.

freestyling. A specific type of first-person view (FPV) flying not dissimilar to an aerobatic demonstration or competition. Pilots, wearing a pair of video goggles, push their aircraft through a series ***of extreme maneuvers.*** Much like drone racing, doing this—and learning to do it—will result in frequent crashes. Expect to become an expert aircraft repair technician along with an expert pilot if you choose to participate in this type of flying.

frequency-hopping spread spectrum (FHSS). A type of radio technology widely incorporated into wireless consumer products, such as WiFi networks and Bluetooth accessories—as well as drone and model airplane control systems. Rather than transmit a signal on a single, discrete frequency, which would be vulnerable to interference, the signal is divided into tiny segments and transmitted on multiple frequencies at random within a defined radio band, such as 2.4 GHz. Thus, even if one segment of the transmission is lost to interference, the overall impact is negligible.

gain. In digital photography, the term "gain" is sometimes used to describe the sensitivity of the sensor to light. However, the term "ISO" is actually much more common, in spite of the fact that it was used to distinguish the size of light-sensitive silver halide crystals on different film stocks and therefore has not the slightest relevance to digital imaging. Change isn't easy, apparently.

Galileo global navigation satellite system (Europe/EU). Galileo is the name given to the global navigation satellite system (GNSS) constellation established by the European Union (EU) which is accessible worldwide. The first of its satellites was launched from French Guana in South American in 2014 and the constellation is managed from a control center in Madrid, Spain. At present, there are 23 operational Galileo satellites in orbit.

global navigation satellite system (GNSS). Global navigation satellite system (GNSS) is a generic term for a constellation of satellites in Earth orbit that transmit radio signals to users on the ground who, with an appropriate receiver, can use them to find their location with a high degree of precision. GNSS constellations with global availability include the United States' Global Positioning System (GPS), China's BeiDou, the European Union's Galileo and Russia's Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS). Most small, civilian drones incorporate a GNSS receiver capable of receiving signals from one, or more, of ***these constellations.*** This data is then used by the flight control system (FCS) to enhance aircraft stability.

Global Positioning System (GPS). The first of the global navigation satellite system (GNSS) constellations to be established, the Global Positioning System (GPS) was originally developed for the United States military. Its first satellite was launched into orbit by the U.S. Air Force in 1978. Befitting its function as a defense project, non-military users were only able to receive less accurate location fixes from the GPS constellation through a program known as selective availability. This was discontinued under a law signed by President Bill Clinton in the year 2000. Today, there are 32 operational GPS satellites in orbit, managed by U.S. Space Command.

Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS). The Global'naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) global navigation satellite system (GNSS) constellation was established by the Soviet Union during the Cold War, in response to the United States' development of the Global Positioning System (GPS). The first of its satellites was launched into orbit in 1982. Following the collapse of the Soviet Union, the Russia took over management of GLONASS, which currently has 24 operational satellites.

global shutter. In digital photography, a global shutter functions in a way that is analogous to the mechanical shutter in a film camera: exposing the entire sensor to the light passing through the lens and the aperture for the entire period of the exposure. Compared with a camera using a rolling shutter, the resulting images are more likely to be clear and free from visual artifacts.

go-around. In aviation, to "go-around" is to abort a landing. Rather than continue an attempt to land in unfavorable or unsafe circumstances, the pilot applies throttle to gain airspeed and climbs away from the approach. Unless they are flying an unpowered glider, all pilots should be prepared to perform a go-around on any landing attempt—and that goes double if you're a new remote pilot still figuring out how to fly.

golden mean. So, when I sat down to write a book about learning how to fly drones and model airplanes, I never imagined myself ***writing a definition of the "golden mean."*** Anyway, here it goes: The golden mean, also known as the golden ratio or the divine proportion, was first recognized by the ancient Greeks, who noted its frequent appearance in nature and geometric theorems. Applied to visual composition, the golden mean suggests that a horizontal rectangular frame should be divided by a line at approximately three-fifths of its total width. This (roughly) reflects the much more modern "rule of thirds" which is applied to photography and visual design. Entire books could, and have, been written about the golden mean. Check it out if you want to, but fair warning: there is a lot of math, and it also gets kind of spooky.

GPS receiver. A radio receiver equipped to receive and interpret signals from the constellation of Global Positioning System (GPS) satellites in Earth orbit. However, along with the term "GPS" itself, "GPS receiver" is often used as a generic descriptor for a system that would be more correctly described as a global navigation satellite system (GNSS) receiver, because most modern "GPS receivers" actually receive signals from multiple constellations. At the risk of coming across as unbearably smug, feel free to point out this error whenever your friends and relatives make it.

ground control station (GCS). Broadly speaking, a ground control station (GCS) is the ground-based hardware that is used to control an uncrewed aircraft in flight. In the case of a large military platform, the GCS can be the size of a building. However, when it comes to drones and model aircraft, the GCS is most often a simple, handheld controller with two joysticks to control pitch, roll, yaw, and throttle, as well as additional nobs and switches that control secondary aircraft functions.

gyroscope. The gyroscope is perhaps most familiar from the children's toy of the same name with a flywheel surrounded by a spherical cage that appears to defy gravity. It accomplishes this startling feat by harnessing the principle of angular momentum. Whereas a child's gyroscope will resist being toppled over owing to its angular momentum, this same force can be used to measure the degree of deflection the gyroscope is experiencing from its original orientation. Early missiles and rockets employed physical gyroscopes that had to be "spun up" before launch as part of their guidance systems. However, the advent of micro electro-mechanical systems (MEMS) has allowed this same fundamental capability to be integrated into computer microchips—as in the flight control system (FCS) of a drone or model airplane.

hand launch. The act of launching a small uncrewed aircraft system (sUAS), most often a fixed-wing airplane, by hand: throwing it like a javelin into the air. Great care needs to be taken while hand-launching an aircraft owing to the immediate proximity of the air. craft's propeller, which could inflict serious injuries to the person doing the launching.

headless mode. Also known as intelligent orientation control (IOC), headless mode is a feature incorporated into some drones that allows the pilot to make control inputs based on their own position relative to the aircraft, rather than the aircraft's direction of travel. While this option can be superficially appealing to novices, it only serves to limit their growth and skills as remote pilots. As Nancy Reagan might have said, "Just say 'No' to headless mode."

head speed. The main rotor of a conventional helicopter turns at a constant rate—known as its head speed—and maneuvers by

changing the pitch of its propeller blades. This differs from drones, for example, which alter the rate of rotation of each propeller relative to the others to maneuver.

heavier-than-air. Heavier than air is a term used to describe an aircraft that does not use buoyancy to achieve flight, including fixed-wing aircraft, rotorcraft, VTOLs and ornithopters.

high wing. A specific configuration of fixed-wing airplane, in which the wing is attached at the top of the fuselage.

inertial measurement unit (IMU). An integrated sensor array that includes micro electro-mechanical system (MEMS) gyroscopes and accelerometers for each axis of rotation, incorporated into all drones and many model aircraft to provide data for the flight control system (FCS). Originally a separate component, today the inertial measurement unit (IMU) has largely been integrated into the FCS.

infrared range finder. A device that sends out a pulse of invisible infrared light and watches for its reflection from an object in the environment. This allows the infrared range finder to determine the distance between the object and the sensor. Previously, these types of sensors were occasionally used for collision avoidance, but today they are used almost exclusively as precise, low-altitude altimeters.

intelligent orientation control (IOC). Also known as "headless mode," intelligent orientation control (IOC) is a flight mode incorporated into some drones that allows the pilot to make control inputs based on their own position relative to the aircraft, rather than the aircraft's direction of travel. While IOC is a tempting alternative for new pilots, it will only limit the growth and development of their skills as remote pilots. As they said when I was coming of age, "Friends don't let friends fly using IOC."

ISO. ISO numbers describe the size of the light-sensitive silver halide crystals on film stock—which basically nobody uses any more, and that goes double for drones. Nevertheless, this completely archaic measure remains the near universally employed measure of the sensitivity of a digital camera's sensor to light. In traditional film photography, ISO numbers generally ranged from 100 to 6400, with the lowest numbers corresponding with less sensitivity to light, meaning that more light is required to create a properly exposed image.

jet. The primary alternative to the propeller as a means to develop thrust for a fixed-wing aircraft. The conventional jet engine works by compressing ordinary air, mixing it with fuel and igniting it inside a combustion chamber. This results in exhaust gases being ejected from the rear of the engine at high speed, pushing the aircraft forward. Jets allow airplanes to substantially exceed the maximum airspeed of their propeller-driven counterparts.

Kelvin (K). Because people are crazy, degrees Kelvin are used to measure two complete separate and unrelated phenomena: the absolute temperature of matter, where the zero-point equals a total cessation of molecular activity; and, the "temperature" of light falling onto a scene, which has absolutely nothing to do with the felt or measured temperature in the environment. Color temperatures range from red to blue, with a candle or the rays of the setting sun rounding out the red end of the spectrum at approximately 1800K and a clear blue sky being the bluest shade of light, at 15000K, or above.

landing gear. More properly known as the undercarriage, the landing gear is the apparatus that allows an aircraft to safely land and taxi across the surface. Typically, the landing gear consists of three wheels, or sets of wheels, arranged in either a tricycle or tail-dragger configuration.

landing roll. The minimum distance a fixed-wing aircraft requires to reach a full stop after its initial contact with the ground. If an aircraft's landing roll exceeds the length of the runway available, that's a bad day for everyone involved. *See* takeoff roll.

latency. Latency is a measure of the time required for a sensor, such as the video camera on board a drone, to capture data and transmit it to the ground-based pilot. As data is carried by electromagnetic waves traveling at the speed of light, some tiny degree of latency is inevitable. When time to encode and decode the data is added

at each end of the process, the latency with conventional drones can be half a second, or more. This is perfectly serviceable for ordinary aerial photography applications. However, a half-second delay would mean disaster for first-person view (FPV) pilots engaged in drone racing or freestyling. To overcome this hurdle, these pilots either use analog systems—which are nearly instantaneous but subject to interference—or more expensive digital systems that drastically reduce the time required for the encoding/decoding process.

launch catapult. A surface-based device used to hurl a fixed-wing aircraft into the sky in a short distance. Apart from free flight (FF) competitors drawing back slingshots to launch their unpowered gliders, launch catapults are essentially unknown in drone and aeromodelling activities. Larger military and civilian drones that are incapable of a rolling takeoff will use launch catapults to get airborne, as will crewed aircraft operating from a confined space, such as the deck of an aircraft carrier. No surprise, systems and spaces that require a launch catapult often must also rely on arresting gear. *See* arresting gear.

lighter-than-air. Lighter-than-air is a term used to describe an aircraft that uses buoyancy to achieve flight, including balloons, blimps, and dirigibles.

lithium-polymer batteries (LiPos). The name given to a Faustian bargain struck between humans who wish to operate small, electrically powered aircraft and the fire-breathing monsters that make this possible. Lithium-polymer batteries (LiPos) are the only widely available power source that store enough energy and can discharge that energy fast enough to make flight powered by electricity viable. However, they bring with them considerable risks. If a LiPo battery is punctured, damaged, charged incorrectly, discharged incorrectly, overheats or is otherwise provoked, it will experience thermal runaway and catch fire. The resulting blaze cannot be extinguished using water or conventional fire extinguishers and emits poisonous smoke. Therefore, proper precautions must always be taken to use, store, charge, and discharge LiPos correctly.

Low-Altitude Authorization and Notification Capability (LAANC). The Low-Altitude Authorization and Notification Capability (LAANC), which is pronounced "lance" by people in the know, is a system that provides real-time, automated access to defined portions of controlled airspace for remote pilots operating either under recreational or commercial rules. The LAANC system is accessed using an application developed by a private third party, working in partnership with the Federal Aviation Administration (FAA). Those areas of controlled airspace which are available for LAANC authorization are identified on the UAS Facility Maps.

low-wing. A specific configuration of fixed-wing airplane, in which the wing is attached at the bottom of the fuselage.

machine vision. The name given to a range of technologies that enable computer systems to interpret visual data captured by digital cameras and other sensors. While this has innumerable potential applications that seem to grow by the day, the most relevant to drone operations are collision-avoidance systems, which use paired cameras—much like binocular human vision—to identify obstacles in the environment and alert the pilot to its location and proximity.

magnetic compass. An instrument, also known as a magnetometer, that detects the presence of a magnetic field and indicates its direction. Far and away the most common application for a compass is to detect the Earth's magnetic field, thereby providing navigators and other travelers to discern which direction is north, even in a featureless environment. A magnetic compass is typically paired with a GNSS receiver on board drones to enhance their autonomous flight capabilities. Because the Earth's magnetic field changes both with the passage of time and at different points across its surface, the compass must be periodically calibrated to ensure consistent results.

main gear. On a fixed-wing aircraft with a wheeled undercarriage, the main gear are the wheels, or sets of wheels, position beneath the wing. These are designed to absorb the shock of landing, unlike the smaller wheel(s) used for steering the aircraft during ground operations.

mean sea level (MSL). Altitude above mean sea level (MSL) is the standard measure of altitude in crewed aviation and reflects the height of the aircraft above the average level of the oceans worldwide. Altitude MSL is distinguished from altitude above ground level (AGL) (the altitude of the aircraft above the local terrain). AGL is the measure typically referenced in drone and model aircraft operations. This distinction is critical, for example, because under most circumstances these operations are limited to an altitude of 400 feet. Therefore, operating a drone or model aircraft at 14,515 feet MSL would get you in big trouble in some places, but if you're flying over Pikes Peak, Colorado, you're still only flying at 400 feet AGL. *See* above ground level.

micro electro-mechanical systems (MEMS) sensors. A fantastical development in semiconductor fabrication that allows the functional equivalent of conventional accelerometers and gyroscopes—as well as compasses and barometric altimeters—to be embedded within integrated circuits. Don't ask me how—I just fly these things.

monoplane. A fixed-wing aircraft with one wing, a design that constitutes the overwhelming majority of airplanes, both crewed and uncrewed, in service today. The monoplane is distinguished from multi-wing airplanes, the most common being the biplane which dominated in the first few decades of powered flight.

multirotor embed. A type of vertical takeoff and landing (VTOL) aircraft employed exclusively in uncrewed system design that effectively embeds a multirotor—most often a quadcopter—within a conventional fixed-wing aircraft. While a relatively inefficient design when compared with other types of VTOLs, the multirotor embed offers a robust, mechanically simple design which makes it appealing to certain users, the armed services principle among them.

multirotor. A type of rotorcraft that employs four, or more, propellers spinning parallel to the ground for lift, thrust and maneuvering. Multirotors were the first type of crewed rotorcraft to fly, but their mechanical and aerodynamic complexity severely limited their practical applications. However, the advent of small, extremely reliable brushless electric motors, inexpensive low-power computing solutions for flight control systems (FCS) and micro electro-mechanical systems (MEMS) sensors resurrected this aircraft type that is today universally recognized as a drone.

multi-wing. A fixed-wing aircraft with more than one wing, the most common example being the biplane. Because multi-wing airplanes are significantly slower than a comparable monoplane, they quickly fell out of favor once structural engineering and materials science enabled the development of single-wing airplanes.

nadir. The full, scientific definition: The point on the celestial sphere that is opposite the zenith and located directly beneath the observer. The definition you will actually remember: If you put a tablespoon of water inside a beach ball, it will always settle at its nadir position—provided that the beachball is in a gravitational field, like the one we have here on Earth. Take that beachball up to orbit and all bets are off.

National Airspace System (NAS). An integrated system of rules, procedures and standards reflected in maps, charts, documents and reports, made manifest by personnel, services, physical infrastructure and equipment, created for the purpose of allowing one billion commercial air travelers to fly within the United States each year in near total safety—while simultaneously overseeing operations by light civilian aircraft, military flight training and operations, emergency response and the integration of small uncrewed aircraft systems (sUAS), while also assuring the safety of people on the ground. Some folks, most especially drone folks, like to complain that the National Airspace System (NAS) isn't moving quickly enough to embrace new technology, but I think that given the total scope of its operations, we should all be grateful that everything works as well as it does.

NavIC (Navigation with Indian Constellation; India). A regional constellation of global navigation satellite system (GNSS) satellites established and maintained by India. NavIC, which is a play on the Hindi word for "sailor" or "navigator," currently has eight satellites in orbit which are only visible from the Indian sub-continent and the surrounding territories. Outside of India, most GNSS receivers do not incorporate the ability to receive NavIC signals. The first satellite was launched in 2013.

neutral-density (ND) filter. In photography, a neutral-density (ND) filter is a filter that reduces the intensity of all wavelengths across the visible-light spectrum passing through the lens by the same amount. This results in a reduction of the total amount of light falling on the camera's sensor without affecting the colors in the resulting image. ND filters are therefore useful in avoiding overexposure.

Notices to Air Missions (NOTAMs). A Notice to Air Missions (NOTAM) is a bulletin that alerts airspace users to temporary circumstances with the potential to affect flight operations. Most NOTAMs are irrelevant to remote pilots, as they concern on-airport or crewed aircraft operations such as the closure of a particular taxiway or the erection of a crane along an approach or landing corridor. However, NOTAMs can also apply to remote pilots, as well, such as when a Temporary Flight Restriction (TFR) is established. Professional remote pilots will also post NOTAMs to alert crewed aviators when drones will be operating in a specific area.

optical flow sensor. A system for enhancing the stability of a drone at low altitude, the optical flow sensor uses a camera facing straight down from the underside of the aircraft. This camera continuously captures images and compares the most recent to the ones that preceded it. By identifying features on the surface below, like the seam in a concrete sidewalk, the optical flow camera is able to assess whether or not the aircraft has moved from one instant to the next. If it perceives a movement is not the result of pilot input but rather an external force, like a gust of wind, the flight control system (FCS) can use data from the optical flow sensor to maintain its current position, along with input from a GNSS receiver and other sensors.

orientation flying. Orientation flying is the conventional approach to remote piloting: the pilot directly observes the aircraft's movements and performance from the ground and gives control inputs relative to its attitude and heading. As the relationship between the pilot and the aircraft's heading is constantly changing, this is a skill that requires considerable practice to master.

ornithopters. One of four major categories of heavier-than-air flying machines, along with: fixed-wing aircraft, rotorcraft, and VTOLs. Ornithopters fly like birds, by flapping their wings.

outrunner motor. A term used to describe a specific type of brushless electric motor, commonly used in drones and model airplanes. The outer portion of the motor, which is comprised of the bell housing, serves as its rotor: spinning when electric current is applied to the motor via an electronic speed controller (ESC). This configuration is described as an "outrunner" because it is the outside of the motor that turns—or runs.

permanent magnet. A permanent magnet always exerts a magnetic field on the surrounding environment owing to its intrinsic properties—like the type you might use to post a family photo on the door of your refrigerator. This makes it distinct from an electromagnet, which only generates a magnetic field when electricity is applied to it.

pitch. One of three axes (the plural of axis) of rotation available to all material objects in the known universe, along with roll and yaw. In aeronautics, the pitch axis defines the relationship between the front of an aircraft and the horizon.

private pilot. A private pilot certificate is issued by the Federal Aviation Administration (FAA) to an individual who has demonstrated their competency to operate a small, civilian aircraft by completing an Airman Knowledge Test (AKT) as well as a practical flight assessment with a Designated Pilot Examiner (DPE). Private pilots are not allowed to fly passengers or cargo for compensation, but it is a required step that all crewed aviators must take before earning additional certificates.

propeller. Two or more symmetrical airfoils joined at a hub that is spun, thereby exploiting the Bernoulli Principle to generate either lift or thrust—depending on whether it spins parallel to the ground (on a rotorcraft), or perpendicular to the ground (on a fixed-wing aircraft), or some of both (on a VTOL).

Public Law 116-283 Section 10002. This law includes a provision that allows students to operate drones and model airplanes under the recreational rules prescribed in 49 USC §44809, provided that they are enrolled in a recognized institution of higher learning, a Junior Reserve Officer Training Corps (JROTC) training program

or an educational program chartered by a Community-Based Organization (CBO). This law also states that the instructors of such programs may also operate under 49 USC §44809, provided that the primary topic of the training is not small uncrewed aircraft systems (sUAS) operations, and that the instructor provides only "minimal assistance" in the piloting of the aircraft.

push rod. A rigid mechanical linkage that connects a servo horn to a control surface on a model airplane, via its control horn.

QZSS (Quasi-Zenith Satellite System; Japan). A regional global navigation satellite system (GNSS) constellation launched into orbit and maintained by the Japanese space agency, JAXA. Fully compatible with the United States' Global Positioning System (GPS) constellation, the Quasi-Zenith Satellite System (QZSS) enhances the precision of location fixes in Japan and across the Asia-Oceania region. There are currently four operational QZSS satellites in orbit. The first was launched in 2010.

radio frequency interference (RFI). A type of interference that affects radio transmissions, like the ones used to control drones and model airplanes. Radio frequency interference (RFI) is created by systems designed to emit radio waves, such as radio and television broadcast antennas, cellular towers, and wireless data networks. Because the Federal Communications Commission (FCC) allocates radio spectrum with the specific intent of avoiding these types of issues, it is rare for RFI to impact small uncrewed aircraft systems (sUAS) operations. "Rare" is good when it comes to a phenomenon that can affect the safety of flight, but it's not the same thing as saying, "It has never happened once in all of recorded human history." Smart remote pilots are always on the lookout for potential sources of RFI.

radio-controlled (RC). A technology used to direct the flight of drones and model airplanes. The pilot holds a radio transmitter with a pair of joysticks, which they use to give control inputs to the aircraft. These are transmitted using frequency-hopping spread spectrum (FHSS) system bound to the aircraft, which responds with the corresponding maneuvers, often through the mediation of a flight control system (FCS).

rate of climb and descent indicator (RCDI). On the flight deck of a crewed aircraft, the rate of climb and descent indicator (RCDI) is an instrument that displays how quickly the plane is gaining or losing altitude. While such movements are often the result of the pilot's control inputs—as when climbing or descending—the RCDI is also useful for determining if a weather phenomenon, such as an updraft or a downdraft, is affecting the aircraft.

receiver (RX). In radio engineering, a receiver (RX) is a device that receives a radio signal and translates it into useful content, such as audio, video, or data. In remote piloting, the RX is bound to a particular control transmitter (TX), otherwise known as a ground control station (GCS) and receives the pilot's control inputs. Wire connectors on the RX send signals to the servos and electronic speed controllers (ESCs) to cause the aircraft to maneuver accordingly. In model aviation, the RX sometimes also contains a simple flight control system (FCS) with basic sensors such as micro electro-mechanical system (MEMS) accelerometers and gyroscopes.

recreational flying. In remote piloting, recreational flying refers to flight operations occurring under 49 USC §44809 which is intended strictly for the pilot's own enjoyment. With a few, narrow exceptions as described under Public Law 116-283 Section 10002, any flight that provides a tangible benefit beyond personal enjoyment must be conducted under 14 CFR Part 107 by a certificated remote pilot in command (RPIC).

relative wind. When an airfoil exceeds its critical angle of attack—that is, when the angle at which the oncoming air meets the airfoil (or, more accurately, its chord line) exceeds a limit defined by its aerodynamic properties—the result will be an immediate and dramatic loss of lift known as an aerodynamic stall. However, if you've ever been to an airshow, you've likely seeing airplanes flying straight up into the sky, their wings at a 90-degree angle to the horizon. It certainly seems like this kind of maneuver should exceed any airfoil's critical angle of attack. The reason it doesn't is the phenomenon known as "relative wind." Fixed-wing aircraft are themselves responsible for creating most of the wind, i.e., the moving air, that they encounter in flight, due to the thrust developed by their motors

or engines. If an aircraft is traveling fast enough, even if it is pointing straight up, the motion of the air around the airfoil will still not exceed its critical angle of attack, because of the resulting relative wind. Of course, unless that airplane has rocket engines powerful enough to lift it into orbit, this is necessarily going to be temporary.

The truth is, unless they are flying directly into a hurricane, fixed-wing aircraft are themselves responsible for generating most of the "wind" they encounter in flight through the thrust developed by their engines or motors, a phenomenon known as "relative wind." Thus, if an airplane is flying fast enough, it can appear to make a mockery of the critical angle of attack, at least for a while

remote identification (remote ID or RID). A requirement put in place in September 2023 by the Federal Aviation Administration (FAA) that requires all small uncrewed aircraft systems (sUAS) weighing more than 250 grams, or any sUAS used for a commercial operation, to carry a short-range electronic beacon that transmits a unique identification code tied to its registration number, speed, altitude and other basic flight information.

remote pilot-in-command (RPIC). The formal title given to an aviator certificated under 14 CFR Part 107 to operate small uncrewed aircraft systems (sUAS) in commercial applications. It is derived from the title given to crewed aviators, being pilot in command (PIC).

retractable undercarriage. A retractable undercarriage (a.k.a., the “landing gear”), also referred to as “retracts,” folds up into the body of an aircraft once it is airborne. This reduces the drag on the aircraft in flight, but also entails increased weight and mechanical complexity.

return-to-home (RTH). A standard feature on drones with sophisticated flight control systems (FCS) equipped with global navigation satellite system (GNSS) receivers, the return-to-home (RTH) function causes the aircraft to return to its launch point autonomously, without further input from the pilot. Typically, RTH is established as the default result in the event communication is lost between the aircraft and the ground control station (GCS).

roll. One of three axes (the plural of axis) of rotation available to all material objects in the known universe, along with pitch and yaw. In aeronautics, the roll axis defines the relationship between the sides of an aircraft and the horizon.

rolling shutters. In digital photography, a rolling shutter functions by capturing each horizontal line of resolution in an image in sequence: one after the other. While this process is nearly instantaneous and will result in images comparable to a camera equipped with a global shutter under most circumstances, a rolling shutter has the potential to create visual artifacts or result in a blurry or distorted final image.

rolling takeoff. A launch procedure used by a fixed-wing aircraft equipped with a wheeled undercarriage. From a standing start, the aircraft accelerates under its own power, rolling across the ground until it achieves a speed sufficient for the lift generated by its wing to overcome the weight of the aircraft. If your aircraft is designed to make belly landings, you shouldn’t expect much success with this approach—unless you consider your aircraft thrashing around on the ground and breaking its own propeller a success.

rotor. In an electric motor, the rotor is that portion of the system that rotates when it is connected to a power source. In an outrunner-configured electric motor, this component is also known as the bell housing.

rotorcraft. One of four major types of heavier-than-air flying machines—along with fixed-wing airplanes, VTOLs and

ornithopters. Rotorcraft, which include helicopters and multirotors, are distinguished by their use of propellers turning parallel to the ground as their primary source of lift.

rotor disk. An imaginary structure that is nevertheless very painful if you stick your fingers into the middle of it, an aircraft's rotor disk is defined by the arc of its spinning propeller(s). In the case of a rotorcraft, the rotor disk can be conceived of as being analogous to an airplane's wing, in that it is a lift-generating body—but that's where the similarity ends.

rudder. A control surface mounted on the trailing edge of an airplane's vertical stabilizer. The rudder is nominally responsible for maneuvering the aircraft in its yaw axis.

rule of thirds. An aesthetic principle applied to photography and other graphic arts which suggests that the subject or other important elements in an image should be placed within the frame at locations defined by a grid that divides it into thirds, horizontally and vertically—like a tic-tac-toe board.

runway. A flat, unobstructed surface built for the purpose of launching and recovering fixed-wing aircraft. To be viable for this purpose, the runway must be at least as long as the takeoff and landing rolls of the airplanes that intend to operate from the facility, plus a safety margin.

sectional charts. A chart published once every 56 days by the Federal Aviation Administration (FAA) for different regions across the country that shows the location of all airports, controlled airspace, and other aeronautical information, as well as major roads, rivers, town, cities, and geographic features, presented at a scale of 1:500,000. Proving definitively that there can be too much of a good thing, sectional charts—referred to as "sectionals"—require patience and training to interpret, given the density of the information presented.

Sensor-Assisted Flight Envelope (SAFE). A trade name for a simple yet effective flight control system (FCS) incorporated into many models and airplane receivers manufactured by Horizon Hobby. When enabled, the Sensor-Assisted Flight Envelope (SAFE) will prevent the pilot pitching or rolling beyond pre-defined limits and will always return the aircraft to straight-and-level fight when the controls are released. Other manufacturers have similar systems with comparable capabilities.

servo horn. A lever arm, typically made of plastic, nylon, or aluminum, which is attached to a servo mechanism on a model airplane and used to actuate one of its control surfaces via a mechanical linkage known as a push rod. Even if it's your own, you still can't toot it.

shutter. In a camera, the shutter is the mechanism that exposes the surface responsible for capturing the image—whether it consists of a digital sensor or film stock—for a precise interval of time, known as the "shutter speed." Shutter speeds can range from a tiny fraction of a second to minutes or hours in the case of celestial photography and is a primary factor in determining whether or not the resulting image will be properly exposed. Digital cameras, like the ones found on virtually all drones, can employ either a global shutter or a rolling shutter.

situational awareness (SA). Situational awareness (SA) is a foundational concept in aviation, but it defies an easy explanation. Much of what I've tried to teach you throughout this book has focused on developing your capacity for SA, although I've avoided using the term for the most part because it can be confusing. Here's my best definition: Every time you go out to fly, you are actually flying two aircraft. The first one is the aircraft in the real world, and the second one is the aircraft inside your head. SA is the art of ensuring that the second aircraft resembles the first aircraft as much as possible in all respects: its location, its performance, and its condition. If you lose SA, for example, the aircraft in your head may have 50 percent battery power remaining, while the aircraft in the real world has 20 percent battery power remaining. Guess which one will determine how long the real-world aircraft keeps flying? Sitting comfortably, reading a book, this seems like a trivial challenge—barely even worth mentioning. However, in actual flight operations, maintaining SA can be a serious problem: one that bedevils even experienced crewed aviators and has accounted

for a surprising proportion of fatal accidents over the years. Here is an old-timey aviation aphorism that I think does a good job of illustrating SA and its importance: "Never let your airplane take you anyplace your brain didn't arrive five minutes beforehand."

six o'clock position. To identify the relative bearing of another aircraft or an external feature, crewed pilots superimpose an analog clock face on top of their aircraft, such that something directly ahead is said to be at the 12 o'clock position. An object which is aligned with the left wing is said to occupy the nine o'clock position, or the three o'clock position if it is aligned with the right wing. Thus, the six o'clock position is directly behind the aircraft. From the earliest days of aerial dogfighting, a position directly behind an opponent has always been recognized as being the most advantageous. For this reason, fighter pilots are assiduously trained to "watch your six"—which is to say: "Watch out for an enemy sneaking up behind you."

small uncrewed aircraft systems (sUAS). An uncrewed aircraft system (UAS)—a category that includes both drones and model aircraft—that weighs less than 55 pounds at takeoff.

smart batteries. Lithium-polymer (LiPo) batteries with a small microprocessor on board, allowing them to manage some of the critical functions required to use them safely. These include self-discharge to a storage charge and maintaining the individual battery cells in balance. When using a smart battery, the end user (i.e., you) simply plugs the battery into the charger and disconnects it when the charge cycle is complete. This eliminates the need to use an old-school LiPo battery charger, which includes a balance lead that must be connected to the battery along with the main charge cable and relies on the user to define the number of cells in the battery, the type of charge cycle, and so forth.

special interest groups (SIGs). Special Interest Groups (SIGs) are organizations within the Academy of Model Aeronautics (AMA) dedicated to a specific type of aeromodelling activities, such as drone racing, competitive soaring, or aerobatics. Some of these charge fees over and above the annual AMA membership dues, while others are free to join. However, all SIG members must be members of the AMA. A full list of active SIGs can be found on the AMA's website: modelaricraft.org.

standard undercarriage. An old-timey term used to describe the tail-dragger undercarriage configuration. This is likely because, for the first five decades of heavier-than-air flight, tail draggers were far and away the most common type of fixed-wing aircraft. However, in the 1950s, the tricycle configuration became the default for virtually all new aircraft designs—and that isn't likely to change anytime soon. Thus, the tricycle undercarriage has been the standard longer than the "standard" configuration. Completely irrational? You bet! However, it's far too late to change it now, so just go with it.

stationkeeping. A maneuver that allows a vehicle—such as an aircraft or a boat—to maintain a fixed position despite the influence of external forces, such as the wind or currents. In the early days of small, civilian drones, stationkeeping required considerable skill and constant pilot input to achieve. However, with the advent of more sophisticated flight control systems (FCS) with global navigation satellite system (GNSS) receivers, this has become an automated function of the aircraft itself. In short, if you're just getting into flying drones right now, you've got no idea how easy you've got it! Also, when I was young, we had to walk to school in the snow—uphill in both directions, no less!

stator. The stator is that portion of an electric motor which is fixed and does not rotate. In an outrunner-configured brushless electric motor, used on virtually all drones and model airplanes, the stator is located inside the motor and contains the electromagnets that cause the outer portion of the motor—called the rotor—to spin.

sterile flight deck. The concept of a sterile flight deck developed in crewed aviation and has nothing to do with preventing the spread of communicable diseases. Rather, the idea is that during high-risk phases of flight—such as takeoff and landing—the aircrew should be focused exclusively on piloting the aircraft. Idle chit-chat and other distractions are prohibited, rendering the flight deck a "sterile" environment. As this requirement was implemented in the interest of safety, an effort has been made to extend the concept to remote pilots. This is the primary motivation behind professional

drone pilots donning those garish vests with "Drone Pilot: Keep Away" written across the back. Based on my own personal experience while flying in public, these seem to draw as much attention as they deflect, so I suppose we'll have to wait and see whether they are the best solution available to us in the long term.

storage charge. A storage charge represents the proportion of a lithium-polymer (LiPo) battery's total capacity at which it is least volatile and best suited for long-term storage. Expressed as a percentage, this lies somewhere between 50 and 60 percent of its total capacity. However, LiPo batteries themselves and old-school model airplane people realize that these percentages are an abstraction and what really matters is the voltage in each battery cell—with 3.7v representing the nominal storage charge.

straight-wing. A phrase used to characterize a fixed-wing aircraft that incorporates a broadly rectangular wing mounted perpendicular to its fuselage. Straight-wing airplanes perform best at relatively low speeds, which made them the unchallenged rulers of the sky before the advent of the jet engine in the 1940s, and they remain an extremely common configuration on crewed, propeller-driven aircraft today—along with the many model airplanes that resemble them.

structural icing. In aviation, structural icing is a phenomenon that occurs when ice forms on the structure of an aircraft in flight. It represents a potentially lethal threat to crewed aviation, where it can increase the drag and weight of an aircraft while simultaneously reducing the lift generated by its airfoils. It can also foul critical instruments like the air speed indicator (ASI) and the altimeter. Ice can form on uncrewed aircraft, as well, and cause many of the same problems. However, for structural icing to occur, the temperature must be below freezing, and water must be present in a liquid form. Except for a professional remote pilot conducting a high-priority mission, these conditions are generally not appropriate for flying drones or model airplanes for fun, so this is largely a point of trivia for recreational operators.

sUAS. *See* uncrewed aircraft system.

swash plate. The swash plate is a complex mechanical system that allows a conventional helicopter to manipulate the shape and performance of its main rotor disk, in response to collective and cyclic control inputs from the pilot. Owing to its complexity, the swash plate requires regular maintenance on both crewed and large uncrewed helicopters to perform reliably.

swept-wing. A phrase used to characterize a fixed-wing aircraft that incorporates a V-shaped wing, such that its wingtips are located aft of the point on the fuselage where the wings are attached. Swept-wing airplanes reduce the turbulence associated with high-speed flight—specifically, speeds that can only be achieved by crewed aircraft powered by jet engines. While some model aircraft will incorporate a swept-wing design to remain faithful to the appearance of their crewed counterparts, these will never even begin to approach the speeds where they would see an aerodynamic benefit from this feature.

taildragger. A three-wheeled aircraft with two large wheels located beneath the wings to sustain the shock of landing and a smaller wheel at the rear of the aircraft used for ground steering. Because the rear wheel is much smaller than the other two, the tail of this type of aircraft appears to drag along the ground while taxiing—thus the name. While taildraggers represented the vast majority of aircraft developed before and during World War II, the tricycle-style undercarriage has been predominant ever since. The taildragger undercarriage is sometimes also referred to as the "standard" configuration.

tailsitter. A type of vertical takeoff and landing (VTOL) aircraft that is positioned like a rocket prior to launch, with its nose pointing straight up into the sky. Once airborne, the tailsitter pitches down, bringing its nose to the horizon and flies like a conventional, fixed-wing airplane. While abandoned as a concept for a crewed aircraft in the 1950s, the tailsitter has re-emerged as a viable option for uncrewed aircraft because of its overall efficiency as the same components are used in both horizontal and vertical flight.

takeoff roll. The minimum distance a fixed-wing aircraft requires when accelerating from a full stop to attain sufficient speed to

achieve flight. It should go without saying that any flight you are hoping will end successfully should begin from a runway that exceeds your airplane's required takeoff roll, plus a safety margin. *See* landing roll.

tandem-rotor helicopter. A helicopter with two rotors, each turning on a separate shaft in a plane parallel to the ground. The principal advantage of tandem-rotor helicopters over other rotorcraft configurations is their ability to carry heavy loads, making them popular among the armed services. The tandem-rotor design is seldom seen among uncrewed recreational and commercial aircraft in part owing to its mechanical complexity, having two separate swash plates and a complex transmission system.

target fixation. A psychological phenomenon experienced by aviators wherein the achievement of one specific goal crowds out other concerns, to the detriment of the overall safety of flight. For example, a drone pilot might become so focused on capturing a particular image that they neglect to maintain visual line of sight (VLOS) or disregard a dwindling supply of remaining battery power. Target fixation can be countered by being aware of the danger, as well as practicing good in-flight procedures, such as routinely checking aircraft telemetry, and so forth.

taxiing. The movement of an aircraft on the surface under its own power. It should go without saying that only aircraft equipped with wheels (or floats, if operating from water) are able to taxi. This is nearly universal among crewed aircraft—except for helicopters equipped with skids, which "hover taxi" by flying slowly at extremely low altitude. Among uncrewed aircraft, the ability to taxi is not a universal trait, with many models designed to intentionally make belly landings and requiring a hand launch or catapult to achieve flight.

telemetry. In aviation and space flight, the transmission of data tracking a vehicle's performance to a location removed from the vehicle itself, such as a ground control station (GCS). Long a feature of crewed and uncrewed space missions, telemetry has become a standard feature of civilian remote piloting since the advent of drones. It allows the pilot to maintain awareness of the aircraft's position, altitude, heading, and battery power remaining, along with many other variables that affect its performance.

temporary flight restriction (TFR). A temporary flight restriction (TFR) is a prohibition against aircraft operations put in place by the Federal Aviation Administration (FAA) for a defined geographic space for a fixed period of time. TFRs are established either to ensure the safety of atypical aviation activities—such as a wildfire response or an air show—or to enhance the security of significant public gatherings, such as major league sports games, concerts, or presidential and vice-presidential movements. TFRs apply to both crewed and uncrewed aircraft, and the pilot is responsible for being aware of any TFR posted for their area of operation.

The Recreational UAS Safety Test (TRUST). A basic test of aeronautical knowledge that all recreational remote pilots are required to complete prior to beginning to fly. The Recreational UAS Safety Test (TRUST) is offered online, for free, by a variety of organizations, including the Academy of Model Aeronautics (AMA), The Boy Scouts of America (BSA) and Embry-Riddle Aeronautical University (ERAU). In truth, TRUST isn't so much a test—in that it is literally impossible to fail—but rather a briefing intended to establish a minimum floor of knowledge for all remote pilots. Recreational remote pilots are required to have a copy of their TRUST certificate on hand while flying.

thermal runaway. A phenomenon which occurs when a cell, or a specific portion of a cell, within a lithium-polymer (LiPo) battery is damaged, either by a physical impact, incorrect charging or discharging, or simply because it is feeling unloved. Heat builds up to the point it can no longer be dissipated into the environment, at which point it increases exponentially and induces the same state in the rest of the battery—resulting in a fire that gives off toxic smoke and cannot be extinguished by ordinary means. This is not a circumstance with which you would ever wish to have first-hand experience.

throttle. An aircraft control input that determines the performance of its motor (or engine). In a fixed-wing aircraft, increasing the throttle will cause the propeller to turn faster, increasing its speed.

Increasing the throttle of a multirotor, on the other hand, will cause it to ascend. However, this isn't the way the throttle works on a conventional helicopter, if you want to get technical about it—which I guess we should because this is the glossary after all. The control which causes a helicopter to ascend is actually the aircraft collective, not the throttle. The collective determines the angle of attack at which the rotor blades meet the oncoming air across the entire rotor disk. Increasing that angle also increases lift, but it also requires more energy. Because a helicopter's rotor turns at a constant speed—its head speed—the motor (or engine) has to increase its output as a result. Therefore, the pilot does not directly control motor (or engine) performance with a throttle. Rather, it responds automatically to changes in the aircraft collective.

thrusters. On blimps and dirigibles, thrusters are small nacelles affixed to the external surface of the envelope or the gondola with propellers attached, allowing the crew to maneuver the aircraft.

thrust-to-weight ratio. Short version: The ratio of an aircraft's thrust to its weight. Slightly longer version: Along with the lift-to-drag ratio, the thrust-to-weight ratio is essential in determining the performance of an aircraft. The more thrust an aircraft develops per unit of mass, the greater its ability to accelerate and climb quickly, all other factors being equal.

thrust-vectoring aircraft. A type of vertical takeoff and landing (VTOL) aircraft that uses jet engines, rather than propellers, across all phases of flight. Rather than tilt the engines or the surface that they are attached to—as in a tiltrotor or tiltwing design—a thrust-vectoring aircraft uses movable nozzles to re-direct the jet exhaust, allowing it to transition between vertical and horizontal flight. A real-world example of a crewed thrust-vectoring aircraft is the British Aerospace Harrier jet.

tiltrotor. A type of vertical takeoff and landing (VTOL) aircraft that tilts its propellers from a vertical to horizontal orientation, and back again, to take off like a helicopter, fly like an airplane once aloft, then land like a helicopter at its destination. The tiltrotor is a fairly common configuration of both crewed and uncrewed VTOLs—to the extent that any type of VTOL can be said to be "common." A real-world example of a crewed tilt rotor is Bell Boeing V-22 Osprey, developed for the United States Marine Corps.

tiltwing. A close cousin of the tiltrotor vertical takeoff and landing (VTOL) type, the tiltwing functions in a similar manner, except that instead of the propellers tilting alone, they are attached to the aircraft's wing—, which itself pitches from vertical to horizontal and back again, taking the propellers along for the ride. Although the type has been the subject of experimental and prototype development in crewed aviation over the years, none of these are at all familiar to the general public. However, the type is seeing renewed interest as a potential configuration for those all-electric, autonomous air taxis we're all supposed to be taking to work any day now.

Toilet Bowl Effect (TBE). The colorful name given by early small, civilian drone enthusiasts for a phenomenon that resembles, well, you know what it resembles . . . A drone under the influence of the Toilet Bowl Effect (TBE) will demonstrate a continuous, swirling motion while aloft. The TBE can manifest itself on any drone equipped with a GNSS receiver if its compass is not correctly calibrated. The solution is to land safely and calibrate the compass.

torque reaction. A specific application of Newton's Third Law of Motion, which states: "For every action there is an equal and opposite reaction." Owing to the torque reaction, if one component of a system rotates—like, say, the main rotor on a conventional helicopter—anything attached to that component must rotate in the opposite direction at a rate that reflects the ratio of the mass between the two objects. Thus, for helicopters to emerge as practical flying machines, it was necessary to create the tail rotor, also known as the anti-torque rotor, to counteract the torque reaction from the main rotor.

translate. Fancy pilot talk for maneuvering a helicopter or other rotorcraft without altering its heading. Thus, when a rotorcraft pilot inputs roll to move sideways, that rotorcraft is properly said to "translate."

transmitter (TX). In radio engineering, a transmitter (TX) is an electronic device that sends out a radio signal carrying information, such as audio, video, or data. In recreational remote piloting,

"transmitter" (along with "radio") is also an informal term that refers to a ground control station (GCS).

trim. A means of adjusting the performance of an aircraft, such that the pilot does not need to maintain steady pressure on its control inputs to achieve a desired maneuver with less effort. In crewed aviation, trim is used and adjusted throughout every flight, as an aircraft is first trimmed for ascent following takeoff, then trimmed again for level flight once it reaches its flying altitude, and so on. In remote piloting, trim is generally only used to ensure that an aircraft flies straight and level when the pilot is not giving it any control inputs.

Trusted Operator Program (TOP). A certification developed by the Association for Uncrewed Vehicle Systems International (AUVSI) for commercial remote pilots to demonstrate that their skills exceed those required to earn a credential under 14 CFR Part 107—which is a pretty low bar, as it doesn't require the pilot can actually fly the aircraft. Three levels of TOP certification are available (creatively named "Level 1," Level 2" and "Level 3.") Levels 2 and 3 require a practical flight assessment (PFA).

tricycle undercarriage. The name given to the typical undercarriage configuration of most modern airplanes, which has two larger wheels below the wings, and a smaller, single wheel below the nose of the aircraft. The tricycle configuration stands in contrast to the tail-dragger configuration, which dominated heavier-than-air flight until the end of World War II. Ever since, the vast majority of new aircraft designs have used a tricycle configuration.

UAS facility maps. The Federal Aviation Administration (FAA) developed UAS facility maps to be used in conjunction with the Low-Altitude Authorization and Notification Capability (LAANC). These maps divided the surface-level controlled airspace surrounding hundreds of airports nationwide into a one-square-mile grid and assigned each square an altitude between 400 feet AGL and zero. Remote pilots may fly in controlled airspace up to the indicated altitude once they have obtained authorization through LAANC.

ultrasonic range finder. A device that sends out a pulse of ultrasonic sound, inaudible to humans, and listens for its echo after it reflects off an object in the environment. This allows the ultrasonic range finder to determine the distance between the object and the sensor with a high degree of precision. Some drones incorporate these systems on the underside of the aircraft as low-altitude altimeters.

uncontrolled airspace. Known within the nomenclature of the National Airspace System (NAS) as Class G airspace, any aircraft—including drones and model airplanes—may operate in uncontrolled airspace without first obtaining permission from air traffic control (ATC). Except when superseded by surface-level controlled airspace in the vicinity of an airport with a control tower, uncontrolled airspace generally exists from the surface to either 700 feet or 1,200 feet above ground level (AGL). However, even when operating in uncontrolled airspace, remote pilots need to remain alert for, and yield to, crewed aircraft and avoid interfering with the operations of any nearby airports.

uncrewed aircraft system (UAS). Uncrewed aircraft system (UAS) is the term used almost universally in industry and professional circles to describe drones and model aircraft. This term refers not only to the aircraft itself, but also the ground-based hardware—like the controller, battery charger, and so forth—necessary to enable it to fly. UAS that weigh less than 55 pounds are specifically described as small uncrewed aircraft systems (sUAS). It is also worth noting that the term "UAS" is predominant only in the United States. Elsewhere in the world, they are known as remotely piloted aircraft systems (RPAS).

undercarriage. That portion of an aircraft that is intended to come into physical contact with the surface during launch, recovery, and ground maneuvering. Sometimes referred to as the "landing gear," the undercarriage can consist of either wheels, floats, or skis, depending on whether the aircraft will operate from land, water, or snow.

variometer. An instrument employed primarily by remote pilots flying model gliders that measures whether the aircraft is ascending or descending, much like the rate of climb and descent indicator (RCDI) on the flight deck of a crewed aircraft. However, since the remote pilot must maintain visual line of sight (VLOS) with their aircraft, rising and falling audio tones are used rather than a visual

gauge. The variometer helps the pilot identify when the aircraft has entered a "thermal"—a column of rising air—which will help keep it aloft.

vertical takeoff and landing (VTOL). One of four major types of heavier-than-air flying machines—along with fixed-wing airplanes, rotorcraft and ornithopters. Vertical takeoff and landing (VTOL) aircraft are capable of ascending directly from a small, unprepared patch of ground like a rotorcraft, then transitioning into fixed-wing flight, like an airplane—thereby attempting to capture the flexibility and efficiency of both aircraft types.

visual line of sight (VLOS). In the context of remote piloting, maintaining visual line of sight (VLOS) is a requirement for most small uncrewed aircraft system (sUAS) operations, including all recreational activities involving drones and model aircraft. Effective VLOS goes well beyond being able to discern the aircraft as a tiny point in the sky. Instead, it is defined by a six-point test developed by the Federal Aviation Administration (FAA) using the acronym "LAADON." VLOS can only be adequately maintained if the remote pilot can determine:

> ***L****ocation:* The position of the aircraft, including distance and direction.
>
> ***A****ltitude:* The elevation of the aircraft above the surface of the earth at its current location, as opposed to the surface where it was launched (which is what virtually all small UAS telemetry reports).
>
> ***A****ttitude:* The aircraft orientation in the pitch, roll, and yaw axes.
>
> ***D****irection of flight:* The aircraft's current heading and anticipated movement through the air.
>
> ***O****bserve airspace:* Keep watch for other aircraft or hazards in the vicinity of the operation.
>
> ***N****ot pose a hazard:* Ensure the aircraft does not endanger people or vulnerable property not directly involved in the operation.

visual observer (VO). A member of the flight crew of a drone or model airplane, the visual observer (VO)—also referred to as a "spotter" in the recreational flying community—is responsible for maintaining visual line of sight (VLOS) with the aircraft, as well as monitoring the surrounding airspace for emergent hazards, such as low-flying crewed aircraft. The VO must be located near enough to the remote pilot to facilitate easy communication. There is never a good reason not to have a VO, but they are advisable or even mandatory, if the pilot is engaged in certain especially distracting activities, such as aerial photography or first-person view (FPV) flying.

vortex ring state. A hazardous aerodynamic condition that affects conventional helicopters making direct vertical descents. As the aircraft descends into its own propwash, its main rotor experiences a phenomenon not dissimilar from an aerodynamic stall. As a result, it loses lift, and the rate of descent increases and becomes uncontrollable. Adding power using the helicopter's collective input—the intuitive solution to this frightening problem—will not arrest this descent. Instead, helicopter pilots are trained to fly forward or sideways to escape the propwash and restore lift.

weight and balance. A procedure required of crewed aviators prior to flight that determines if the weight and placement of personnel and cargo on board an aircraft will have an adverse impact on its center of gravity (CG). This is a critical part of the pilot's job, as if the CG moves beyond limits established by the aircraft's designers, the results could be catastrophic.

white balance. White balance refers to a system in digital cameras that accounts for the color temperature of the light falling across a scene, to ensure that objects that are white in the real world appear to be white in the images it captures. White is used as the standard point of reference in making this determination, but proper white balance ensures the fidelity of all colors across the spectrum.

wind. The movement of air over the surface of the Earth in a particular direction at a constant speed. Wind is a critical factor for aviators to understand, in much the same way sailors must understand ocean currents, as it plays an important, or even a decisive, role in aircraft performance. If the speed of the wind changes frequently

and abruptly, the results are described as gusts. The irregular movement of air caused by its interaction with terrain or objects on the ground, among other sources, is known as turbulence.

yaw. One of three axes (the plural of axis) of rotation available to all material objects in the known universe, along with pitch and roll. In aeronautics, the yaw is defined as rotation around the object's vertical axis and determines the point on the horizon that the object is facing as would be defined by a compass heading. Put another way, yaw can be recognized as steering a conventional ground vehicle or watercraft.

zenith. The full, scientific definition: The point on the celestial sphere that is opposite the nadir and located directly above the observer. The definition you will actually remember: If you fill up a beach ball with water, leaving only a tiny bubble of air inside, that bubble will always settle at its zenith. If you haul this beach ball into a zero-gravity environment, I make no warranty, expressed or implied.