

January/February 2020

FAA ^{BRIEFING} *Safety*



Federal Aviation
Administration

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and Maybe a Tire and a
Strut Too



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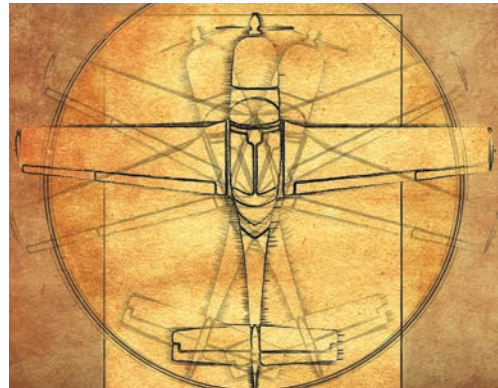
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ABOUT THIS ISSUE ...



The January/February 2020 issue of *FAA Safety Briefing* focuses on how to better "Know Your Aircraft." Feature articles cover each major section of an aircraft, highlighting the many design, performance and structural variations you'll likely see and how they affect your flying. We'll also take a fresh look at understanding aircraft energy management.

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FAA **BRIEFING** Safety

The FAA safety policy voice of non-commercial general aviation

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A DANGEROUS THING

Seventeenth century English poet Alexander Pope is usually credited with the famous remark that “a little knowledge is a dangerous thing.” Obviously, Mr. Pope lived long before the age of aviation. Nevertheless, his observation is applicable to aviation both in its general interpretation and its literal form.

Here’s what I mean.

How (Not) to Describe an Elephant

One way to paraphrase the first and more common interpretation is to say that we don’t know what we don’t know. All too often, though, we humans have a tendency to inflate the importance and scope of even the tiniest scrap of information. That idea best comes to life in the famous story of the six blind men and the elephant: each describes the animal based on the one part they happened to touch. The crew resource management discussion in the previous issue of this magazine translates the concept into aviation terms, emphasizing the importance to combining information from all available sources to get an accurate understanding of the situation.

More is Better

A second way to interpret Pope’s remark is the more literal one — that is to say that not knowing enough about something can be dangerous. I think you will quickly agree that when it comes to doing any job in aviation — pilot, mechanic, controller, dispatcher, or any other you can name — the danger of insufficient knowledge is obvious. So, in this “know-your-aircraft” themed issue of *FAA Safety Briefing*, the team will take a closer look at each of the major parts of our marvelous flying machines.



**WHEN IT COMES TO DOING
ANY JOB IN AVIATION, THE
DANGER OF INSUFFICIENT
KNOWLEDGE IS OBVIOUS.**

Clearly, of course, it would take a lot more than a single magazine issue to do justice to any given part of any given aircraft make and model. Our purpose is to cover some of the basics, which could be new to those just getting started or a useful reminder to those who have been in aviation for a while. For everyone, though, the team hopes that the material presented here will whet your appetite for more knowledge about the design, the construction, and the performance of your particular make and model.

Here’s a preview.

We’ll start with a look at the importance of knowing all you can master about avionics and automation. As the article observes, the advent of

“glass” in place of the once ubiquitous “six-pack” makes some aspects of flying easier — but only if you first invest the time it takes to truly master the system(s) you have. We go on to a look at powerplants, with discussion of both legacy and developing engine types. On the subject of airframes, there’s still a lot of metal out there but the team also takes a look at composites, and things you should know about each. You will also find concise reviews of handling/inspection tips for the hardworking tailfeathers, the all-important wings, and the sometimes-overlooked elements of your landing gear.

With winter now upon us, flying days might be less frequent. But we hope you will be inspired to use this non-flying season to dig in and deepen your knowledge of these topics.

Energy Management

In the spirit of tying it all together — an aircraft is always more than the sum of its individual parts — we are pleased to offer the first of perhaps several articles on the vital topic of energy management. If you have looked at the Airman Certification Standards (ACS) recently, you will note several references to this concept as one of the elements a pilot should be able to know, consider, and do to qualify for a certificate or rating. With contributions from the aviation training community, we are already in the process of developing more guidance material on this topic for inclusion in a future issue of our H-series handbooks. One of those contributors has generously offered to start sharing those concepts though this publication, so don’t miss it.

AVIATION NEWS ROUNDUP



Cold Temperature Restricted Airports Update

Last October, the FAA issued Information for Operators (InFO) 19012 (go.usa.gov/xpb2q) that provides an update to the Cold Temperature Restricted Airports list. This year's update contains several additions and deletions to the list. The list was developed in response to recognized safety concerns over cold weather altimetry errors at certain airports. It is available in the Notice to Airman Publication at go.usa.gov/xpb2A.

ADAPting to ADS-B

The ADS-B Out equipage deadline has passed, but it's not too late to equip. The FAA encourages owners to equip as soon as possible to enjoy the benefits of ADS-B and ensure access to all available airspace.

If your aircraft does not meet ADS-B Out equipage or performance requirements, either because you have not yet equipped or your equipment is not working properly, you may

request an authorization to deviate from the rule to access ADS-B Out required airspace.

The FAA has developed an ADS-B Deviation Authorization Preflight Tool (ADAPT) to manage these non-routine authorization requests. ADAPT requests should be made via the web tool no more than 24 hours before your flight and no less than one hour before the flight. Authorizations are processed on a first-come, first-served basis and are prioritized with other duties. Pilots are responsible for receiving an authorization from ADAPT before departure.

Please note: the FAA will not issue in-flight authorizations to operators of non-equipped aircraft, nor will ATC facilities accept requests for authorizations by telephone.

For more information on ADAPT, please visit www.faa.gov/go/equipadbsb.

Basic Facts About BasicMed

Established at the direction of Congress, BasicMed is a medical quali-

fication that allows pilots who meet certain conditions to operate an aircraft without a "traditional" FAA medical certificate. As of November 2019, more than 51,000 airmen have met the qualifications and are operating under BasicMed. This number is expected to grow, both in the United States and elsewhere, as certain International Civil Aviation Organization (ICAO) member countries consider enacting similar programs.

BasicMed is consistent with the FAA's strategic initiative for risk-based decision-making because it is limited to certain types of lower-risk operations. It incorporates mitigations and safeguards that include limitations on the size of the aircraft and the number of passengers, as well as requirements for regular medical examinations and recurring aeromedical education.

BasicMed enables airmen to speak frankly with their physicians to find and address health issues before these factors contribute to an accident or incident. Accordingly, the program is



also consistent with the core tenets of the FAA's Compliance Program.

The FAA is focused on continuous improvement through the use of data, which is why Congress requires a report on this program in 2022. The FAA is actively monitoring the regulation and will use this data to inform Congress of any issues, to include ways to improve this program and to inform future decisions and actions.

Those interested in flying under BasicMed can visit [FAA.gov/go/BasicMed](https://www.faa.gov/go/BasicMed) to learn more about the process.

TWEB and TIBS in Alaska Sunset

As part of FAA efforts to modernize and streamline service delivery, Flight Service discontinued the Transcribed Weather Broadcast (TWEB) and Telephone Information Briefing Service (TIBS) in Alaska on Jan. 1, 2020. This will allow the agency to reallocate resources in ways that enhance services to users.

The TWEB was a continuous broadcast of aeronautical and meteorological information over a limited network of Very High Frequency Omni-Directional Range (VORs) and Non-Directional Beacons across Alaska. Flight

Service created TWEB when there was a large demand for briefings to alleviate the workload of specialists and reduce wait times for pilots. A similar broadcast service, known as Hazardous Inflight Weather Advisory Service (HIWAS) is being discontinued in the contiguous United States (CONUS).

TIBS was a continuous telephone recording of meteorological information that pilots could access without going through a Flight Service specialist. Since the early 1980s, the broadcast allowed pilots to access weather information along the route of flight but did not satisfy the requirement to become familiar with all available information prior to a flight. TIBS was discontinued in the CONUS in September 2018.

With the advent of the internet and other technology, the demand for information from Flight Service specialists has declined. There are multiple other sources available for weather and aeronautical information, which are often presented in an easier to understand graphical format.

Radio Frequency Reduction Update

As part of efforts to modernize and streamline service delivery, Flight

Service is in the process of decommissioning duplicate or redundant Remote Communication Outlet (RCO) frequencies, while maintaining at least 90-percent of the current coverage 1,000 feet above ground level. The FAA published a final policy notice ([go.usa.gov/xpjbq](https://www.faa.gov/xpjbq)) to begin reducing the network of RCOs in August 2017.

Effective February 20, 2020 at 0001z, the FAA will issue Notices to Airmen (NOTAMs) for the final list of RCOs and VOR voice frequencies slated for removal, which will no longer be monitored. The FAA will realize estimated cost savings of about \$2.5M annually in maintenance costs alone, as well as a reduction in infrastructure costs of about \$40K per month. The completion of radio frequency reduction aligns RCO infrastructure with the decrease in pilot demand for inflight services and excludes frequencies designated for emergency or military use and those in Alaska. Please visit [faa.gov/go/flightservice](https://www.faa.gov/go/flightservice) to see an updated list of frequencies.

SAFETY ENHANCEMENT TOPICS

Please visit bit.ly/GAFactSheets for more information on these and other topics.



JANUARY

Interruptions and Distractions

Learn how to successfully cope with interruptions and distractions while flying.



FEBRUARY

Mountain Flying

Understanding the need for training and currency when flying in mountainous areas.

A LIST AT LONG LAST

Probably the most consistent question I get when talking to airmen is, “Why isn’t there a list of approved medications from the FAA?” The answer was always that the request was actually far more difficult than most people understood. Having an approved list means having one not only for you, but also for every other pilot across all classes of medical certification as well as alternative qualifications. But that has changed.

The Challenges

Several major issues have always made this holy grail of aerospace medicine a herculean task. First, every medication can have different effects on different people. Any list of approved medications would have to cover any potential impairment for any airman. In many cases, medications that seem innocuous (e.g., Diphenhydramine/Benadryl®) can have dangerous side effects. Next is the fact that no two illnesses/diseases are identical. That leads to point three: the underlying condition for which you are taking the medication could be disqualifying. These issues only scratch the surface of our required considerations.

But we understand that there is a challenge for airmen as well. Ultimately, an airman is responsible for determining whether they are fit for flight under Title 14 Code of Federal Regulations (14 CFR) section 61.53. We understand that such a list is a valuable resource in making that determination.

The Long Awaited Prize

The General Aviation Joint Steering Committee (GAJSC) requested a list as part of an effort to educate pilots on

Drug Facts	
Active ingredient (in each tablet) Chlorpheniramine maleate 2 mg	Purpose Antihistamine
Uses temporarily relieves these symptoms due to hay fever or other upper respiratory allergies: ■ sneezing ■ runny nose ■ itchy, watery eyes ■ itchy throat	
Warnings Ask a doctor before use if you have: ■ glaucoma ■ a breathing problem such as emphysema or chronic bronchitis ■ trouble urinating due to an enlarged prostate gland Ask a doctor or pharmacist before use if you are taking tranquilizers or sedatives	
When using this product ■ You may get drowsy ■ avoid alcoholic drinks ■ alcohol, sedatives, and tranquilizers may increase drowsiness ■ be careful when driving a motor vehicle or operating machinery ■ excitability may occur, especially in children If pregnant or breast-feeding, ask a health professional before use. Keep out of reach of children. In case of overdose, get medical help or contact a Poison Control Center right away.	
Directions	
adults and children 12 years and over	take 2 tablets every 4 to 6 hours; not more than 12 tablets in 24 hours
children 6 years to under 12 years	take 1 tablet every 4 to 6 hours; not more than 6 tablets in 24 hours
children under 6 years	ask a doctor
Other information store at 20-25° C (68-77° F) ■ protect from excessive moisture	
Inactive ingredients DSC yellow no. 10, lactose, magnesium stearate, microcrystalline cellulose, pregelatinized starch	

the dangers of certain medication use while flying. Working with the GAJSC, the Office of Aerospace Medicine has produced a document to help guide pilots in making that fitness decision.

The guide opens with a preamble that discusses factors you should know and consider when using it. First, evaluate your condition, then examine the medication for obvious warnings such as “Do not operate machinery.” Next you need to be able to determine what exactly you are taking. The document provides a guide to over the counter (OTC) drug labels that should help because you can often find the same active ingredient in many different brand names and sometimes for treating different symptoms. Prescription drugs won’t feature the standardized label, but do indicate what they are and usually a common trade name.

Multiple Choice

When evaluating a possible medication, keep in mind the two primary concerns for aeromedical fitness are subtle and sudden incapacitation. Will this medication degrade your performance in a way that you will be unable to detect? Will this medication

cause you to lose consciousness with little or no warning? When you have a choice, this guide can help you pick an option that should be safe to use.

For example, let’s take a look at some common cough/cold medications. Most medications not labeled “PM” are usually safe for flight, but there are some exceptions. It’s important to look at all the active ingredients. Anything that contains dextromethorphan (that includes Dayquil®) is not allowed. Another common ailment is gastrointestinal illness. Medications containing bismuth subsalicylate like Pepto-Bismol® or Kaopectate® are fine, but those containing Loperamide, like Imodium®, are not. It’s a good idea to test out a medication prior to using it while flying in case you have an adverse reaction.

It would be easy to view all of those medications as roughly equivalent, but from an aerospace medicine point of view, they are not. This is why this guide has such great potential to help airmen treat illness while staying safe. The guide is a reference, but ultimately, you are still the final authority.

Dr. Michael Berry received an M.D. from the University of Texas Southwestern Medical School, and a master's in preventive medicine from Ohio State University. He is certified by the American Board of Preventive Medicine in aerospace medicine. He served as an FAA senior aviation medical examiner and vice-president of Preventive and Aerospace Medicine Consultants for 25 years before joining the FAA. He also served as both a U.S. Air Force and NASA flight surgeon.

LEARN MORE

What OTC Medications Can I Take and Still Be Safe To Fly?
www.faa.gov/go/pilotmeds



MAY I HAVE YOUR ATTENTION, PLEASE!

Certification with Attention Deficit/Hyperactivity Disorder (ADHD)

Attention deficit/hyperactivity disorder (ADHD, also known as attention deficit disorder (ADD)) is a chronic disorder. Commonly diagnosed in childhood, it can persist into adulthood.

ADHD is also diagnosed in adulthood. An estimated two to four-percent of adults in the United States have ADHD. It is an aeromedical concern due to impairments of attention, hyperactivity and impulsivity, leading to judgment and decision-making problems. Accordingly, the FAA requires a detailed evaluation of an applicant for medical certification. Naturally, this generates many questions.

ADHD manifests itself differently in adults than children. In an adult, inattention, restlessness, and impulsivity are more prominent while hyperactivity recedes. Inattention issues include problems with organization, prioritization, task completion, forgetfulness, and missed deadlines. Maintenance of attention for long periods (e.g., cruise phase of a routine flight) can be difficult for someone with ADHD. Executive function is also impaired, manifesting through problems in working memory (the ability to hold information long enough to solve a problem), task management, and multi-tasking. Over-reaction to frustration is frequently present. Clearly, these deficits can be hazardous in the aviation environment.

Individuals with ADHD are also at risk for other mental health diagnoses, substance abuse, and relationship problems. Traffic violations are more common, raising concerns for risky behavior. A recent review of NTSB data linked nine fatal mishaps to ADHD or ADD.

The cause of ADHD is not clear, but there is a genetic component. Its development is also linked to expo-

ADHD IS AN AEROMEDICAL CONCERN DUE TO IMPAIRMENTS OF ATTENTION, HYPERACTIVITY AND IMPULSIVITY, LEADING TO JUDGMENT AND DECISION-MAKING PROBLEMS.

sure to cigarette smoke, alcohol and other drugs, and environmental toxins such as lead. Brain injuries are also implicated. The diagnosis of ADHD requires a comprehensive evaluation by a licensed clinician who gathers information from those who know the individual, including family members, co-workers, and teachers. For an adolescent or adult to receive a diagnosis of ADHD, the symptoms need to have been present before age 12. Unfortunately, over-diagnosis is not unusual.

While there is no cure for ADHD, available treatments can reduce symptoms and improve function. Treatments include medication, psychotherapy, education or training, or a combination of these. Medications used for ADHD can have side effects that are not compatible with flight safety; therefore, the FAA cannot authorize their use. The FAA will consider other treatment modalities on a case-by-case basis.

The FAA has recently simplified its protocols for evaluation of the diagnosis of ADHD, either current or historical. Airmen with a history of ADHD/ADD get a screening battery. Also, individuals who have taken stimulant medications for other reasons (e.g., fatigue) must be screened even with-

out diagnosis of ADHD/ADD. These medications include amphetamine, methamphetamine, and methylphenidate (not a true stimulant). The FAA no longer requires a full neuropsychological testing battery unless the screening battery is abnormal.

To be considered for a medical certificate, the applicant must be off all medications used to treat ADHD for a minimum of 90 days. Medical records are reviewed and, if possible, observations made by those who know the individual in a variety of environments. School transcripts (on and off medications, if ever taken), performance reports, etc., are also reviewed. The applicant must complete a series of neurocognitive tests, some of which have been normed for the pilot population. These help assess the applicant's cognitive ability off medications. Fortunately, we are able to qualify many applicants for medical certification. In fact, in many cases, the evaluator determines that the individual actually never had ADHD/ADD.

As always, our goal is to certify as many applicants as we can when safety permits.

Leo M. Hatrup, M.D., received bachelors' degree from Wichita State University, a master's in public health from Harvard University, and a doctorate from Vanderbilt University. He is retired from the U.S. Air Force in which he spent the majority of his career in aerospace medicine. He is board certified in aerospace and occupational medicine. He is a certificated flight instructor and enjoys flying airplanes, helicopters, and gliders.

LEARN MORE

Airmen can find information describing the steps necessary for certification here: bit.ly/2CZobso



HAVE YOU EQUIPPED?

**You must be equipped with ADS-B Out to fly
in most controlled airspace.**

FOR MORE INFO VISIT
faa.gov/go/equipadsb



**Federal Aviation
Administration**

—ADS-B—

SEE AND BE SEEN

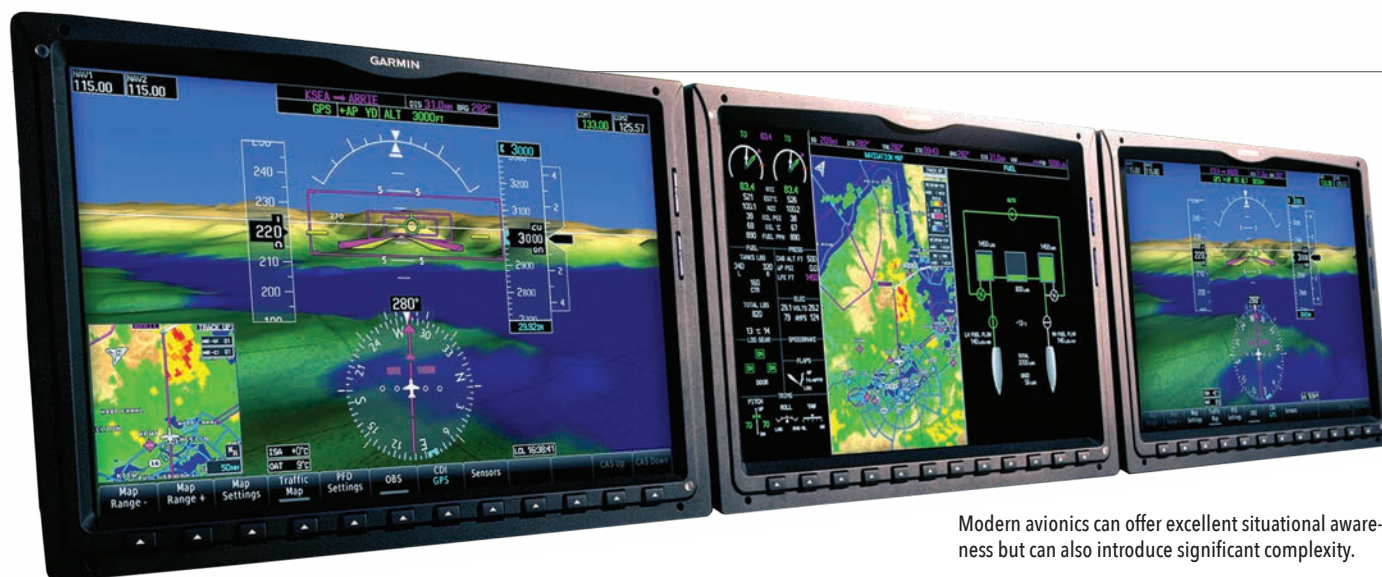
NO SURPRISES!



Keeping Control of Avionics and Automation

By Susan Parson

Along with “Oh [expletive!],” “What’s it doing *now*?” might now be one of aviation’s best-known memes. Not so very long ago, most GA airplanes sported the same familiar six-pack of gauges in the panel. Sure, some pilots were lucky enough to have whiz-bang LORAN navigation or maybe a horizontal situation indicator (HSI). As for automation, well, even the simplest one-axis autopilots were not exactly standard issue.



Modern avionics can offer excellent situational awareness but can also introduce significant complexity.

Adding to Your “A” Game

Things are very different today. When pilots ask me what the “aviate” part of the familiar aviate/navigate/communicate mantra means in practical terms, I used to explain that it means maintaining control of attitude, airspeed, and altitude. Today, though, we need to include another pair of “A” words: **avionics** and **automation**.

As with many changes, the rapid adoption of jetliner-level avionics and automation is one of those good news/bad news developments. The good news is that these technologies offer GA pilots an unprecedented level of situational awareness on everything from aircraft control/performance to traffic, terrain, and weather. The not-so-good news is that the complexity of this technology can quickly transform a Pilot in Command to a Pilot in Confusion.

We are all vulnerable to this hazard. Programming is generally easier now than it was in the 1.0 versions, but managing modern avionics/automation still requires a substantial amount of heads-down time. The risk for confusion further expands for pilots who don’t specialize in a single brand of avionics. If you flew one six-pack, you knew them all. With glass, though, manufacturers like Aspen, Avidyne, and Garmin all have different ways of arranging buttons and performing functions. Things get even dodgier when you pilot “Frankenplanes,” my preferred term for older birds with a mash-up of newer avionics stitched in.

But wait — there’s more. When everything works right, or as expected, our gadgets tempt us to neglect not only our see-and-avoid responsibilities, but also a vast swath of the flight management work. They lull us away from the discipline of critical thinking and true situational awareness, which means a lot more than knowing your physical location.

It all adds up to two simple facts. First, avionics and automation do reduce some kinds of pilot workload, but they create a whole new set of tasks. Second, a pilot who steps out of the loop by shirking these tasks will inevitably encounter a time when everything is perfect ... until suddenly nothing makes sense.

Leading Edge vs. Bleeding Edge

To keep cutting-edge avionics equipment from hurting you, your passengers, and/or your airplane, being Pilot in Command (PIC) now includes more than just mechanical manipulation of stick and rudder. It also means mastery of three key flight management skills: *information management*, *automation management*, and *risk management*.

Information Management. An axiom of aviation training is that the volume of information is akin to drinking from a fire hose. Learning new avionics/automation equipment follows that pattern. Even without diving into sub-menus, a pilot can be drenched in data but thirsty for useful information (e.g., how to find a specific piece of information). To know your avionics means using your preferred combination of apps, simulation software, manuals, and time on the flight deck to understand the system on two levels.

So-called “knob-ology” is the most obvious, and you do need to master the basic functions of each control interface. This part of information management includes both actual buttons and electronic versions presented on a screen.

It is perhaps even more important to master the system at the conceptual level. Knowing how your system is organized is far more effective (and far less frustrating) than attempting to memorize every possible sequence of button pushes, pulls, and turns.

The next phase of information management is learning to meter, manage, and prioritize the information flow to accomplish specific tasks. For this task, you might find it helpful to direct the fire hose information flow into a few conceptual drinking glasses. These include personal preference (e.g., map orientation and configuration) and phase of flight (e.g., map scale for en route vs. terminal area).

Automation Management. The automatic flight control system, otherwise known as the autopilot or more affectionately, “George,” can be a lifesaver. Like a mischievous child, though, George can also make trouble for an unwary pilot. At the most basic level, managing automation first means knowing how the system works (aka “knobology”). It also means knowing at all times which modes are engaged,

and which modes are armed to engage. To reinforce this mindset, I always require pilots to read the display out loud. For example: Heading mode is ENGAGED, and aircraft is following the heading bug on the e-HSI to intercept the desired course. Navigation mode is ARMED to capture the desired course upon intercept. Altitude hold mode is ENGAGED to maintain pre-selected altitude of 4,500 MSL.

Keep in mind that George may not be the only piece of automation you need to manage. Depending on the system, you may or may not need to adjust sensitivity of the course deviation indicator (CDI) needle for the appropriate flight operation. Similarly, you may or may not have to switch the active navigation from GPS to LOC for an ILS or localizer approach.

While on the subject of navigation source, sound automation management also requires a thorough understanding of how the autopilot interacts with the other systems. With some installations (especially on the “Frankenplane” retrofits), changing the navigation source from GPS to LOC or VOR while the autopilot is engaged in NAV course tracking mode can cause the autopilot’s NAV mode to disengage.

The good news is today’s avionics offer GA pilots an unprecedented level of situational awareness. The not-so-good news is that its complexity can quickly transform a Pilot in Command to a Pilot in Confusion.

Risk Management. Pilots who permit advanced avionics and automation to lull them into a passenger-in-command role are likely to find some very sharp corners in this cutting-edge technology. Good risk management of this technology requires that you:

- *Know the limits.* Even if the panel of a GA airplane looks more modern than its airline counterpart, there are still limits to what a light GA aircraft can safely do.
- *Never trust; always verify.* The magenta line can very efficiently lead you into regulatory or topographical trouble.
- *Stay engaged.* One of the best techniques for situational awareness is callouts — even for single pilot operations. Callouts help you make the most of your gadgetry, while keeping you firmly in the role of PIC. They are also a great way to catch your programming mistakes.
- *Set Tripwires.* If you find yourself baffled, confused, or in any way uncertain about what the technology is doing, it’s time to turn it off and reorient yourself.

Left Seat = Right Stuff

You had to demonstrate mastery of all the proverbial right stuff before you were allowed to take the left seat as PIC. No matter how capable the avionics and automation appear to be, keep it in its proper place and never vacate your seat to mere technology. ▶

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ADS-B Avionics

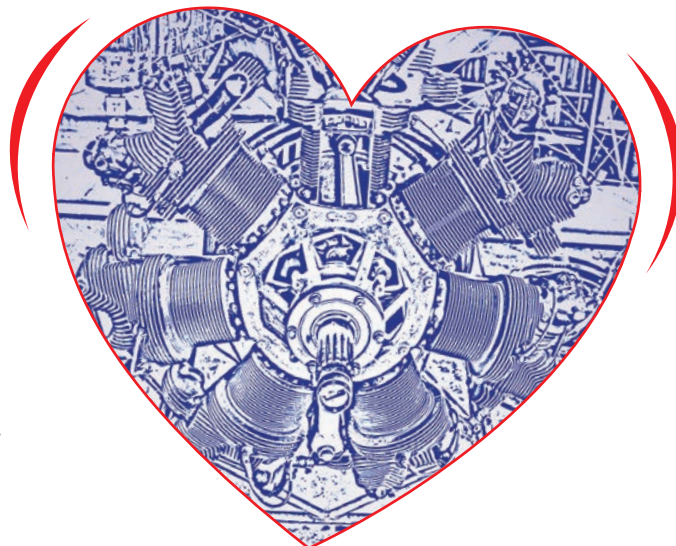
ADS-B is an environmentally friendly technology that enhances safety and efficiency by moving from today’s ground-based radar and navigational aids to precise tracking using satellite-based, GPS technology. With ADS-B Out, your aircraft automatically broadcasts its own three-dimensional, position information (latitude, longitude, altitude) and other location details including heading, ground track, and groundspeed to air traffic control and to other aircraft that are equipped with ADS-B In, thus greatly improving situational awareness for you and other aircraft around you. The precision provided by ADS-B allows your aircraft to fly more directly from point A to B, saving time, money, and reducing fuel burn and emissions. You’ll also enjoy more efficient spacing and optimal routing in non-radar environments, including the busy airspace in the Gulf of Mexico, mountainous regions of Colorado, and the lower altitudes of Alaska. Air traffic controllers tracking ADS-B Out-equipped aircraft now have much better information about last reported positions and velocity, effectively taking the “search” out of search and rescue.

If you choose to add avionics and displays for ADS-B In, you will see, for the first time, what controllers see: displays showing other aircraft in the sky, and the location of aircraft and equipped ground vehicles on airport surfaces — even at night or during heavy rainfall. ADS-B In cockpit advisory services are free and transmit automatically to your device delivering visual displays of traffic, important flight information such as temporary flight restrictions or closed runways, and pinpointing hazardous weather and terrain to help you to make more efficient route decisions.

While it’s true that ADS-B In provides an unprecedented level of situational awareness, don’t become complacent by over-relying on the technology or spending too much time in “heads-down” mode gazing at the colorful displays. Always remember your see-and-avoid responsibilities and don’t forget to fly the aircraft first.



The Beating Heart



How Your Engine Works and How to “Treat” It

By James Williams

An airplane's engine is the closest thing it has to a heart. The engine provides the energy that not only propels the airplane, but also runs all of the other systems. The engine turns the alternator that provides the electricity. It runs the various pumps that power systems like hydraulics, pressurization, etc.

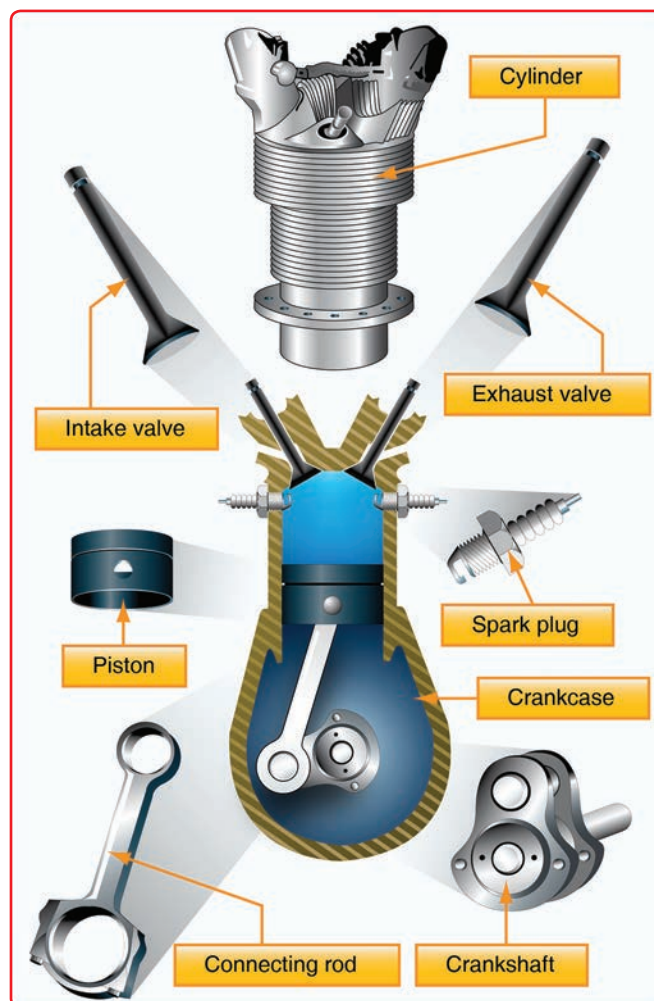
For most of us in general aviation, an engine means an internal combustion engine. Specifically, it means a reciprocating engine, a term that simply denotes the back and forth motion of the pistons. The goal of the engine is to transform potential energy stored in fuel into mechanical energy that powers your airplane, with the help of some air.

Basic Anatomy

An engine has several basic components. First is the cylinder, where combustion occurs. Next is the piston, which nests inside the cylinder from the bottom and provides the compression for, and absorption of energy from, combustion. Supporting the piston is the connecting rod, which transmits energy down to the crankshaft, transferring it out of the engine, usually to a propeller.

As its name implies, the cylinder head sits on top of the cylinder and houses critical components like valves and spark plugs. The valves open to allow the air and fuel mixture into the cylinder (the intake valve) and to allow combusted gases out (the exhaust valve). The spark plug ignites the compressed fuel and air, transforming that chemical energy into mechanical energy that spins the crankshaft and turns the propeller.

Now that we know the basics, let's see how these parts work together.



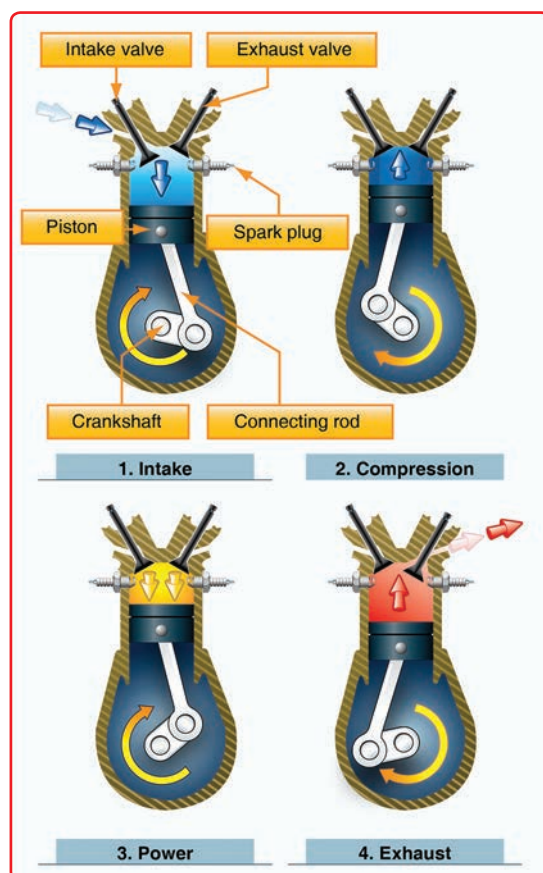
Main components of a spark ignition reciprocating engine.



The crankshaft is shaped to accommodate each piston being in a different position during the firing sequence. That's what provides the energy for the non-power strokes.

And One, Two, Three, Four, Repeat!

Aircraft engines are, with few exceptions, four-stroke engines with four distinct phases: intake, compression, power, and exhaust. During the intake stroke, the piston lowers from the top of the cylinder while the intake valve opens to let in the fuel/air mixture. The compression stroke begins when the intake valve closes and the piston begins to rise toward the top of the cylinder. The power stroke kicks off when the spark plug ignites the compressed fuel/air mixture, causing combustion that pushes the piston back down forcefully. The exhaust stroke starts when the piston reaches bottom dead center and begins to rise again to push out burned gases through the open exhaust valve. Then we start all over again. Although we break the process down into separate steps, the reality is that it is more of a continuous process.



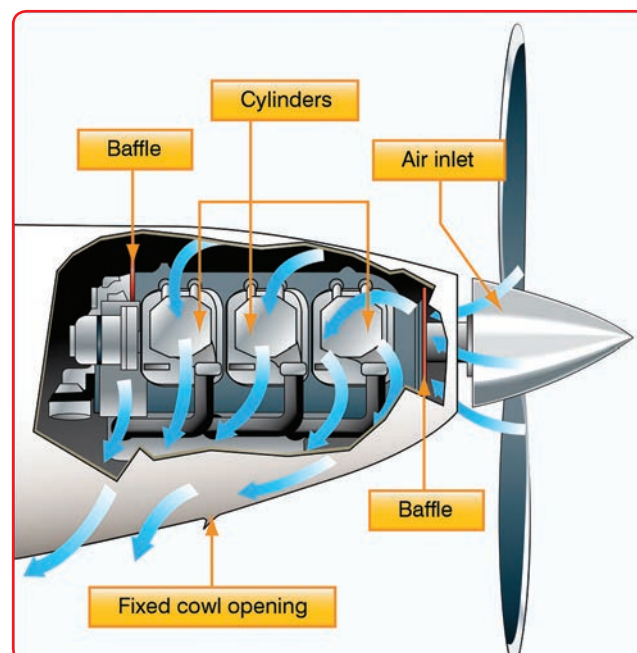
The arrows in this illustration indicate the direction of motion of the crankshaft and piston during the four-stroke cycle.

Supporting Cast

Engine cooling is one of the systems that helps your engine work. Internal combustion engines turn most of the energy from combustion into waste heat. While most of that is sent out through the exhaust, a significant amount of heat remains. Our engines are generally air cooled, so logic suggests that more air equals better cooling. Consequently, the nacelle contains ducts and baffles that direct air flow evenly across the engine's cooling surfaces, thus keeping the engine's operating temperature balanced. If these baffles are removed or damaged, excessive heat buildup in part of the engine can lead to additional wear and possibly failure.

In addition to cooling, an engine needs air and fuel. An intake manifold guides the mixture into the cylinder and fuel is added via the carburetor or fuel injectors. The carburetor remains the most common solution. Carburetors are the older technology but have the advantage of being a well-tested, less complex, and very reliable solution.

Never forget to check the oil, which is the lifeblood of the engine.



Outside air aids in cooling the engine.



An airplane's engine is the closest thing it has to a heart. The engine provides the energy that propels the airplane and runs all the other systems.

Fuel injection allows greater control and greater efficiency, but is more complex. Carburetors do have one distinct disadvantage: carburetor icing can choke the engine. Carb heat is a simple solution to this specific problem, but you do have to activate it.

Then there's the exhaust system, which transfers the spent gases and heat out of the cylinder. The exhaust system ushers the hot combustion gases safely out of the engine compartment and into a muffler. Despite its humble description, the exhaust system is absolutely safety critical. For more information, take a look at the article, "(Un) Holy Smoke! The Nightmare of Smoke, Fire, and Deadly Gas," in our September/October 2019 issue at <https://adobe.ly/34ckY59>.

One way to get more power from an engine is to increase the amount of air and fuel in the cylinder during combustion. This can be done through forced induction, more commonly called turbocharging or supercharging. Turbocharging is more common in today's GA airplanes, but both techniques essentially do the same thing. They compress intake air to force more air and fuel into the engine than normal atmospheric conditions will allow. The difference is that turbocharging uses the engine's exhaust gases to power the compressor while a supercharger taps the engine's power output. For more information on forced induction, see "The Bigger Bang Theory" in our May/June 2015 issue (p.26) at go.usa.gov/xpPxz.

Heart Health

Now that we know how the airplane engine works, let's look at a few ways this "heart" can run into trouble. During preflight, it's important to look for any evidence of leaking

or damaged fuel or oil lines. Visually check connections to the greatest possible extent; loose wires or lines can chafe and quickly turn a minor issue into a major emergency.

Never forget to check the oil, which is the lifeblood of the engine. It helps transfer heat from the hot parts of the engine to areas where it can be safely dissipated. More importantly, it lubricates the engine so that it can function efficiently. Oil starvation, whether from leakage, burning, or just breakdown is one of the common causes of airplane "cardiac" events. Also bear in mind that oil degrades over time, becoming less effective at its job. Regardless of the cause, insufficient lubrication can result in serious damage. Monitoring not just the amount of oil but also its condition during preflight is critical.

Modern avionics and engine tracking systems have made detecting problems a more proactive process. Data analysis can allow for intervention before an emergency. When coupled with a better understanding of the engine and a thorough preflight, they can be a major positive force. It's always better to find a problem in the data rather than in the air. ▶

James Williams is FAA Safety Briefing's associate editor and photo editor. He is also a pilot and ground instructor.

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The Arthropod's Revenge

By James Williams

How the Airplane's Fuselage Has More in Common With Bugs Than Birds

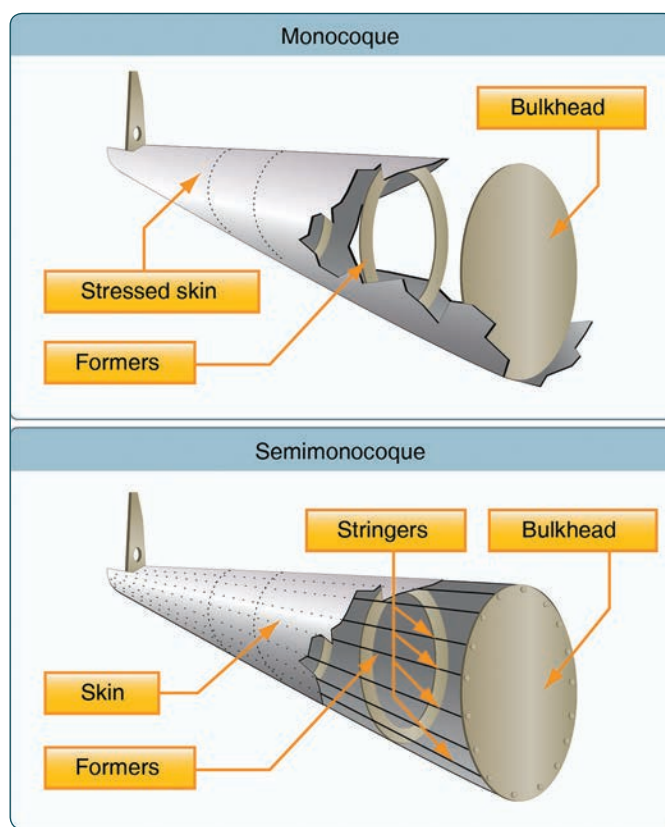
Creepy as it might be, “bugs” and their cousins might be a more apt analogy for an airplane than a bird. For starters, a modern airplane’s fuselage functions as both a skin and a skeleton, a feature that resembles an arthropod more closely than members of the avian family.

One of the key features of arthropods is their exoskeleton, which combines the protective attributes of a skin with the structural attributes of a skeleton. This feature relates to an aircraft’s skin, which is actually a structural load bearing part.

Monowhat?

Modern airplanes are built using a method called monocoque construction. This method uses stressed skin as the main structural component. To help visualize this, think of a soda can. The skin sits around two bulkheads, or formers (the top and bottom of the can), providing a surprisingly strong unit when undamaged. Key advantages of monocoque construction include high strength, light weight, and increased internal volume potential. An important goal with aircraft design is to have the lightest airplane that can hold the most stuff (e.g., people and cargo) while being rugged enough to withstand the rigors of flight.

Monocoque construction does have a few drawbacks. Even small dents or dings can potentially weaken the structure. You can run your own experiment to prove this point. Take any empty soda can (undented) and apply a downward force on the top. You’ll be surprised by how much force the can will withstand. Now make a slight dent in the can and



Semi-monocoque and monocoque fuselage design.



Photo by Tracy Potter, Hagerstown Aircraft Services.

The internal construction of a semi-monocoque airplane showing damage from a wildlife strike.

watch how little force is required to crush it. That's a perfect example of the Achilles heel of monocoque construction.

To counter this problem, manufacturers use a method called semi-monocoque construction, which incorporates reinforcing stringers that run longitudinally between the bulkheads and formers. This method allows some of the stress to be transferred from the skin to the structural reinforcement. It makes the structure more robust but adds weight and complexity to the finished product.

Composite Composition

We often talk about composite materials as futuristic or high tech, but that's not really true in many cases. In its most basic definition, a composite is a combination of two or more different materials, in which all individual properties of the material are preserved. The best example is decidedly low tech: concrete. Concrete is a combination of cement and small rocks and stones (called aggregate). These are the two requirements for a composite material: a matrix or binder (the cement) and a reinforcement (the aggregate). The reinforcement makes up most of the volume and carries most of the load, while the matrix holds the reinforcement together and allows it to be shaped. In aviation, we use things like fiberglass and carbon fiber that follow the same principle. A glass fiber, sometimes woven into fabric, is laid down as the reinforcement and then a resin or glue is applied as the matrix. This is usually done in several layers to provide strength.

Shaping is actually one of the key advantages of composites. It's far easier to create smooth, rounded, or complex shapes with composites than with traditional

materials. Weight can be another advantage of composites but that depends on the material. While carbon fiber can have dramatic weight savings over metal construction, fiberglass generally does not.

The use of composites has slowly grown in general aviation. It started with small, non-structural parts like wing tip fairings and wheel pants but has progressed to the whole aircraft. We usually see fiberglass in GA because the cost is substantially lower than carbon fiber. Fiberglass also allows manufacturers to try designs that would be very difficult or impossible to build in metal.

Taking Care to Keep Yourself in the Air

Regardless of material, an airplane's fuselage is more akin to the exoskeleton of an arthropod than a vertebrate body. Birds have a skin that is important, but it isn't a structural member. When combined with muscle tissue, birds' skin provides some padding around their "structure" and offers some protection when "dented or dinged." But airplanes and arthropods wear their skeleton on the outside. This is why spotting potential damage during preflight is so critical.

What to look for varies depending on the material. Metal aircraft can be easier to inspect because metal deforms from impact force. For example, if an Aviation Maintenance Technician (AMT) drops a tool while working on the aircraft, you will see a dent. Significant dents, dings, and punctures should be referred to an AMT to be evaluated. When in doubt, err towards caution. As with the soda can example, the actual dent might not look all that bad, but it could cause significant risk by compromising the monocoque.

In the case of composites, it's possible for the material to

Regardless of material, an airplane's fuselage is more akin to the exoskeleton of an arthropod than a vertebrate body.

Photo courtesy of Pipistrel Aircraft.



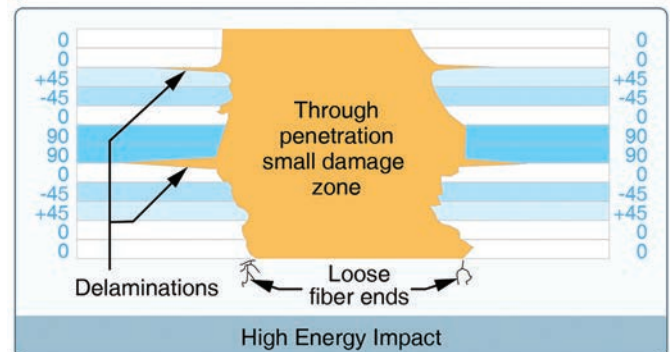
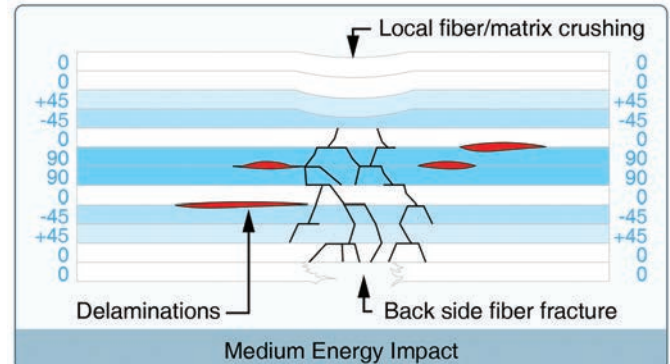
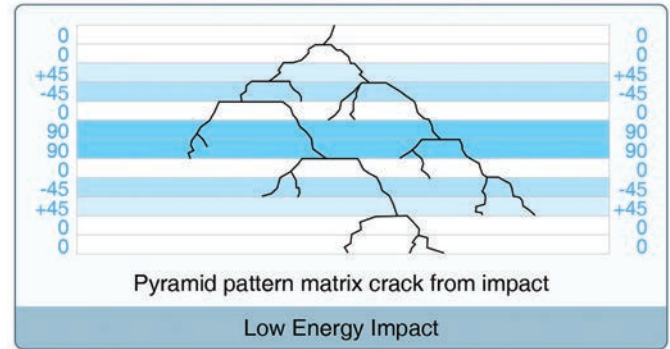
Applying resin to a woven fabric style of reinforcement is one common method of creating a composite material.

absorb an impact without showing damage or to bounce back into shape after impact. Unfortunately, such “invisible” damage can cause delamination between the layers of fiber, or cracks in the matrix that can weaken the structure. This is why you need to have an AMT with composite experience evaluate any impact. The appearance of a whitish area in a composite may indicate delamination below.

With composites, there are also possible issues with extreme heat damaging the resin. Much depends on the particular resin system used for the aircraft, but some resins can weaken above 150°F. While that seems out of reach, remember that aircraft are often parked in warm climates where sun, asphalt, and dark paint can combine to push temperatures to 220°F. The simple fix is to paint composite structures white, which helps keep temperatures below 140°F. Other sources of heat damage include exhaust leaks and minor fires that are quickly extinguished — like those from overheated brakes or electrical faults. Any potential thermal damage should be evaluated carefully before returning the aircraft to service.

Final Thoughts on the Fuselage

The fuselage doesn't attract the attention of an airplane's avionics or its engine. It's not analyzed as closely as its wings or preflighted as intricately as its empennage. It is



Impact energy affects the visibility, as well as the severity, of damage in composite structures. High and medium energy impacts, while severe, are easy to detect. Low energy impacts can easily cause hidden damage.

an aircraft's skeleton. It plays a critical role without much fanfare. But like any skeleton, its faults and failures can be at best disabling, and at worst crippling. Understanding at least a little about it will help you detect any flaws before they become real problems. ▶

James Williams is *FAA Safety Briefing's* associate editor and photo editor. He is also a pilot and ground instructor.

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FAA Pilot's Handbook of Aeronautical Knowledge – Chapter 3
bit.ly/2rK57Mq



L'Empennage

A Guided Tour of Your Plane's Tail Feathers

By Tom Hoffmann

I consider myself to be a decent dart thrower. It helped being able to live in London for a year where the game is known to have its medieval roots. As my interest in the sport grew, so did my curiosity about the types of darts I used, as well as understanding how all the different parts and pieces worked. I was intrigued when learning how critical “flights” are to the stability of a dart’s trajectory, and how design variations can cater to an individual’s throwing style. Flights are the tail part of the dart, typically made of plastic, paper, or even feathers. If you’ve ever tried tossing a flight-less dart, you’ll see exactly how critical they are.

The stability-inducing properties of flights work similarly for arrows and, by extension, aircraft. In fact, the word empennage, which describes the tail assembly of an aircraft, derives from the French term *empenner*, to feather an arrow. The empennage is considered one of the five major components of an aircraft. It includes the entire tail assembly, comprising both fixed surfaces (vertical and horizontal stabilizers) and moveable control surfaces (rudder, elevator, and trim tabs). These components work together to provide stability and control around an aircraft’s yaw and pitch axes.

Doing It the Wright Way

Look no further than the Wright Brothers’ body of work for evidence of how important yaw and pitch control was in finalizing a successful Wright Flyer design. In their early

glider concepts, the Wrights struggled mightily with adverse yaw. When they raised a wing after a turn, the aircraft sometimes slipped in the opposite direction and spun into the ground — a result notoriously dubbed “well-digging.”

It took some tweaking and scores of test flights, but they soon realized the key to controlled flight was adjustable rudder control. After a significant “aha” moment, they cleverly combined their wing-warping mechanism for aileron control to include the rudder, introducing a moveable tail that provided additional stability. While their initial design schemes called for the elevator to be forward of the pilot and separate from the rudder, experiments with their later *Model AB* design proved that the elevator controls worked



The Wright Flyer Model B paved the way for the conventional style empennage we see in most aircraft today.

Copyright Smithsonian Institution



An assortment of aircraft tail designs: (l-r) T-tail, twin-tail, conventional, V-tail, and a conventional tail with a stabilator horizontal stabilizer.

best when located at the back of the aircraft. Shortly thereafter, the Wrights ushered in the *Model B*, or the “Headless Wright,” the first of their aircraft to use the conventional style empennage we predominantly see in today’s aircraft.

Birds of a Different (Tail) Feather

Just as in dart flight variations, there are variations of aircraft tail assemblies, each with its own unique aeronautical benefits. Although it has evolved slightly from the *Model B*, the most common arrangement is the tried-and-true conventional tail design, which consists of a single vertical stabilizer that intersects with a two-part horizontal stabilizer at the end of the fuselage. You’ll see this century-old configuration on everything from a Boeing 787 to a Cessna 152.

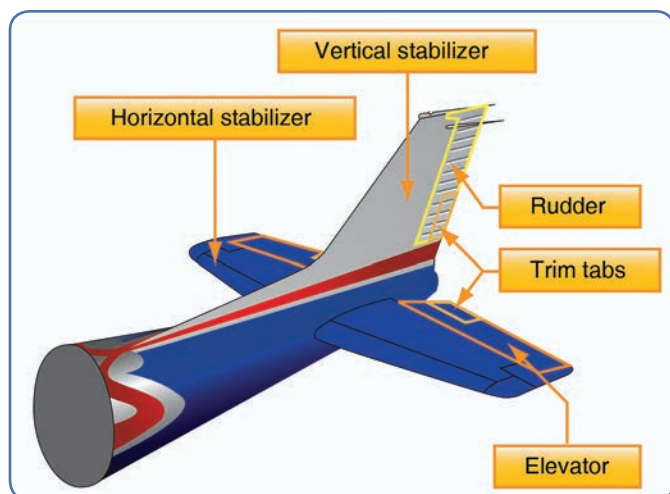
The T-tail design is a popular variation of the conventional style, but with the horizontal stabilizer positioned on top of the vertical fin in the shape of the letter “T.” This configuration increases the efficiency of the horizontal stabilizer since it remains outside the effects of prop wash and wing wake. However, due to their placement, T-tails impose a greater bending and twisting load on the vertical stabilizer, requiring a stronger and often heavier structure. The configuration also requires a more complex elevator cable run and makes preflight inspection of the elevator

more difficult. Be sure to consult your Airplane Flight Manual for any specific preflight inspection procedures, as well as any inflight loading limitations.

Some common GA examples of the T-tail design include the Piper *Tomahawk*, the Beechcraft *Skipper* and gliders like the Grob 103. This empennage style more safely accommodates parachute and cargo operations for aircraft like the Boeing C-17. Although commonly reserved for aft-podded military or business jet aircraft, a further variation of the T-tail is the cruciform tail in which the horizontal stabilizer is moved part way up the vertical stabilizer. A good GA example of the cruciform tail design is the Rockwell *Commander* 112/114 series.

That brings us further down the alphabet to the V-tail, the claim-to-fame design for the Beechcraft *Bonanza* V35. The intent of this design was to consolidate the control surface functions of the rudder and elevator with two slanted tail surfaces to reduce weight and drag. These “ruddervators” would deflect in the same direction when used to control pitch, and in opposite directions when used to control yaw. One drawback is that V-tail pilots have to contend with an undesirable rolling motion (the “*Bonanza* Boogie”) that occurs away from a turn and which must be countered with aileron input. This adverse coupling is one reason why the manufacturer switched to a conventional tail in later *Bonanza* models.

Another empennage style worth mentioning is the dual or twin-tail design, which consists of two small vertical stabilizers on either side of the horizontal stabilizer. A prime example is the ERCO *Ercoupe*, which has its share of faithful followers. One of those *Ercoupe* enthusiasts happens to be author, race pilot, and frequent contributor to this magazine, William Dubois, who is quick to point out its unique safety features and handling prowess. “The rudders are inter-connected to the yoke and the nose wheel on most ‘Coupes, so there are no rudder pedals in the cockpit, and no ball to step on,” says Dubois. This design keeps the plane in coordinated flight at all times. Dubois adds that if the plane is rigged properly, it can’t spin, since you can’t enter a stall uncoordinated. However, this configuration also prevents you from being able to slip the aircraft and requires you to crab to the runway during a crosswind landing.



Empennage components



It's important to always be familiar with what type of control and trim surfaces are installed on your aircraft so they can be properly inspected during preflight.

It's Under Control

Within each of the tail assemblies discussed here are the moveable control surfaces — the rudder and elevator — which allow the pilot to control yaw and pitch respectively. Some empennage designs incorporate the elevator function into a one-piece horizontal stabilizer, known as a stabilator, which pivots from a central hinge point. Although stabilators are more commonly found on military jets (their design aids with efficiency of pitch control at supersonic speeds), airplanes like the Piper *Cherokee* and the Cessna 177 do sport this design.

A key benefit of a stabilator is that it generates a large pitching moment with minimal control force effort, but that can also make the elevator a bit touchy and easy to over control. This design includes an anti-servo tab, which deflects further and in the same direction as the stabilator to increase the control force feel for the pilot. Anti-servo tabs can also be found on aircraft with more traditional elevator designs, like the sprightly AA-1 *Yankee*, to provide additional stability.

Staying Fit and Trim

Since we're on the subject of trim controls, let's run through the other types of tabs you might come across. A balance tab works in the opposite manner of the anti-servo tab, in that it moves in the opposite direction of the control surface changing its relative position. This allows the pilot to reduce or eliminate control pressure requirements during steady state flight conditions. More common is the single trim tab system attached to the trailing edge of the elevator or rudder. These small mechanically or electronically adjustable airfoils are used to eliminate an unbalanced pitch or roll condition during flight without having to move the primary flight controls. Some multi-engine

airplanes use rudder trim tabs to aid with yaw control during single engine operations.

Yet another type of tab you'll often see on rudders are the ground adjustable tabs. As their name implies, these stationary metal tabs are designed to be bent on the ground in order to correct for left or right skidding tendencies in cruise flight.

On Closer Inspection

It's important to always be familiar with what type of control and trim surfaces are installed on your aircraft so they can be properly inspected during preflight. Are all surfaces properly installed and secured, including any hardware, fasteners, hinges, and counterweights? Have you checked for normal directional movement, including trim controls? Was there any maintenance performed recently? Discovering an improperly rigged flight control in flight can get ugly fast.

When preflighting your empennage, also check the condition of any antennae, lights, cargo doors, and if possible, your Emergency Locator Transmitter (ELT). Keep an eye out for loose or missing rivets, wrinkled or damaged skin, and any bouts of hangar rash, to which the tail is particularly prone. Oh yeah, you might want to remove that tail tie down too!

While differences in empennage styles abound, its core function across all aircraft remains vitally important. Hopefully this information has introduced and/or reinforced some helpful pointers on better understanding your bird's tail feathers. Keeping this important part of your aircraft regularly groomed and maintained will help you stay safe and get the most out of your aircraft. ▶

Tom Hoffmann is the managing editor of *FAA Safety Briefing*. He is a commercial pilot and holds an A&P certificate.

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Pilot's Handbook of Aeronautical Knowledge, Chap. 6, Flight Controls
[go.usa.gov/xpKBR](https://www.faa.gov/xpKBR)



The WING'S The THING

How Wing Design Affects Your Ride, and How to Preflight for Safety

By Jennifer Caron


Admit it — there are things you don't know, but *should* know, about aircraft wings. In particular, do you know how their shape or design determines the type of flying you experience, or pros and cons of different wing types? Although wings are the “heart of the aircraft,” too often they do not receive a proper pre- or post-flight examination. Critical parts such as pitot tubes and aileron balance weights are often overlooked.

Read on to learn more about your aircraft wings, the pros and cons, and how to properly inspect them before and after your flight.

The shape and size of a wing greatly affect an aircraft's performance.

1. Wing Placement

Some might argue that the difference in wing placement (high versus low, etc.) is chiefly a personal preference, but there are some important variations in aircraft performance to consider. Here are some general pros and cons of each.

Wing Placement	Pros	Cons
High-Wings: (Cessna 172, Aeropilot Legend 600 Light-Sport) 	<ul style="list-style-type: none"> • Greater stability, particularly at slower speeds • Better downward visibility • Greater roll stability • Higher center of lift • Shorter landing distances • Ideal trainer for new pilots • Easier landing during roundout and flare • Earlier warning of impending stall 	<ul style="list-style-type: none"> • In-flight traffic visibility impaired upward • Impaired visibility in base to final turn (inside wing) • Less maneuverable • Fueling access

Wing Placement	Pros	Cons
Low-Wings: (Piper Cherokee, Mooneys, Beechcraft Bonanza)	<ul style="list-style-type: none"> • Better maneuverability and lighter body • Upward and forward visibility of in-flight traffic • Better visibility in base to final turn • Lower interference drag • More lift and steeper climbs • Higher airspeeds • Better fuel volume 	<ul style="list-style-type: none"> • Less downward visibility and ground clearance • Floating and ballooning during landing flare • Less warning of impending stall



Figure 1

2. Wing Structure

Many high-wing airplanes are semi-cantilevered, meaning they have external bracings or struts attached to the fuselage. Positioned halfway out on the wing, they help support the wing and carry aerodynamic and landing loads. A few high-wing and most low-wing airplanes have a full cantilever wing that's designed to carry loads without external bracing. Aircraft with a full cantilever wing structure are much stronger than aircraft using external braces.

Strut-braced wings, in general, stiffen and strengthen the airframe while allowing a lighter overall aircraft. For example, a biplane with its two, strut-braced stiffened wings is lighter and stronger than a single-winged, braced monoplane. The downside to external bracing is additional drag, reduced speed, and less fuel economy, whereas a monoplane is more efficient with the lowest drag.

One key part of a wing that is often overlooked or unknown is balance weights (Figure 2).

Pilots know about the two control surfaces attached to the rear or trailing edges of the wings: ailerons and flaps. Ailerons extend from about the midpoint of each wing outward toward the tip. Flaps extend outward from the fuselage to near the midpoint of each wing. However, many pilots are not familiar with the function of balance weights, which are used to balance out an aircraft design in the ailerons (as well as elevators, propellers, and engines) and eliminate or reduce excessive vibration (flutter). If not controlled, flutter can result in damage or failure to not only the stabilizers and the wing itself, but also to the ailerons and elevators, as they're more prone to this type of dangerous vibration.

Aileron balance weights are teardrop shaped and are located at the leading edge of each of the ailerons ahead of the hinge line (typically three on each aileron). It is important to check balance weights at each and every preflight, as flying without balanced controls can spell disaster.

3. Wing Shape/Planform

The shape and size of a wing greatly affect an aircraft's performance. Three factors are used in wing design to modify the overall aerodynamic characteristics of flight: aspect ratio, taper ratio, and sweepback.

Aspect ratio, the length and breadth of the wing, has an important effect on a wing's lifting capabilities and drag (Figure 3). An increase in aspect ratio with constant velocity will decrease drag (induced drag), especially at high angles of attack, improving wing performance in a climbing attitude.

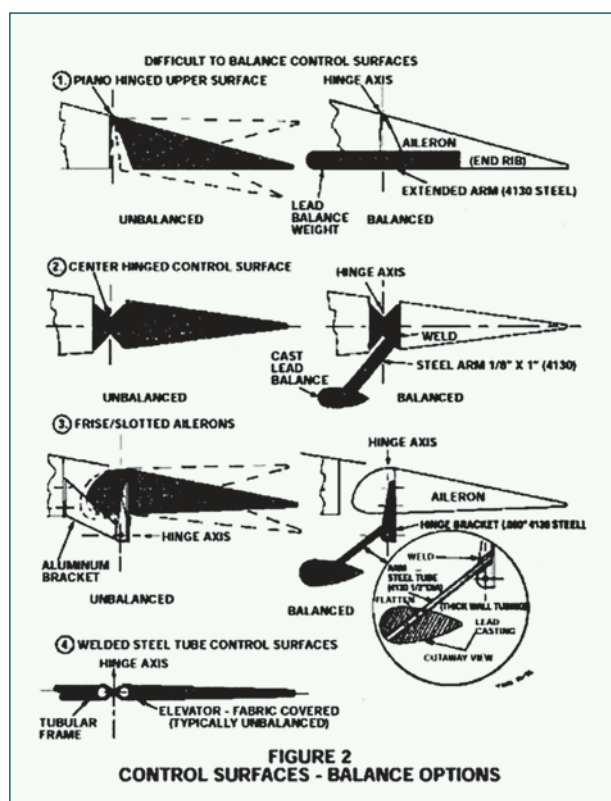


Figure 2

Courtesy of the Experimental Aircraft Association.



Wing Aspect Ratio	Pros	Cons
High Aspect: (Gliders/Sailplanes, Long Hauls, Transport Loads) 	<ul style="list-style-type: none"> • Aerodynamically efficient • Greater lift • Uses less fuel • Greater roll stability • Smaller wingtip equals less induced drag equals better performance in takeoffs, landings, cruise, and climb 	<ul style="list-style-type: none"> • Less maneuverability and more parasitic drag • Wings must be stronger to support air loads, i.e., heavier/expensive to prevent bends and twists to structure • Less fuel volume
Low Aspect: (Piper Cherokee, Aerobatics) 	<ul style="list-style-type: none"> • Greater maneuverability • Lighter structure • Greater fuel volume • Thicker wingtip equals less parasitic drag equals high speed performance • Cheaper to make 	<ul style="list-style-type: none"> • Less lift and reduced roll stability • Greater induced drag and reduced speed • Uses more fuel

Figure 3


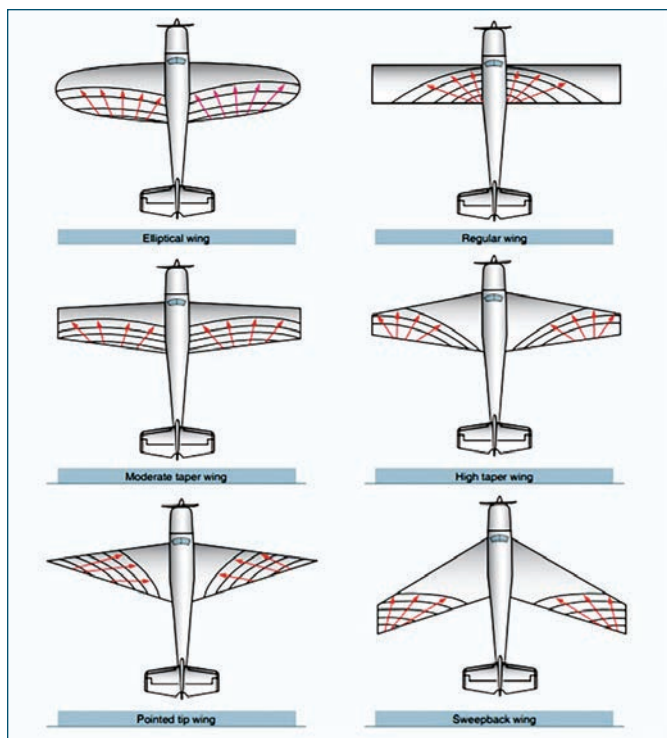
Wing Design	Pros	Cons
Rectangular: (Piper Tomahawk)	<ul style="list-style-type: none"> • Stable airfoil and wing control • Adequate stall warning at wing root with aileron control • Ideal for trainers and low speed aircraft – easy to fly and land • Cheaper, easier to make and design 	<ul style="list-style-type: none"> • Greater induced drag • Less efficient than elliptical wing
Tapered: (P-51 Mustang) 	<ul style="list-style-type: none"> • Lower induced drag • Higher aspect ratio equals greater lift • Greater fuel volume 	<ul style="list-style-type: none"> • Stalls at tips, wing washout required
Delta: (Homebuilt Dyke JD-2 Delta Kitplane)	<ul style="list-style-type: none"> • Greater maneuverability/stability • Ideal for sub- and super-sonic • Large fuel volume • Cheaper to make 	<ul style="list-style-type: none"> • Increased induced drag due to design • High angle of attack to maintain lift

Figure 4



Different types of wing planforms.

A thin, long wing for instance has a high aspect ratio and therefore a better lift to drag ratio. It's more aerodynamically efficient, generates more lift with less drag, consumes less fuel, and is ideal for sustained flight in subsonic aircraft. Longer wings are not as maneuverable as shorter wings, but they're best at low speeds and high altitudes, and are usually more forgiving of improper pilot techniques. Most training and GA airplanes are operated at high coefficients of lift and require high aspect ratios.

Low aspect ratios are seen in thick, wide wings. A decrease in aspect ratio provides a corresponding increase in drag. Very low aspect ratios result in high wing loadings, high stall speeds, and higher fuel consumption. They provide greater maneuverability than wings with high aspect ratios, but what you get in movement, you lose in speed and fuel.

The majority of typical GA aircraft have aspect ratios that range anywhere from 5-9 (gross Aspect Ratio); homebuilts: 4-7; gliders: 20-35; and supersonics: 3-5.

4. Wing Design

Taper ratio and the sweepback, or rearward slant of a wing, are two other design ratios used in wing design. Tapering (decreasing the length of chord from the root to the tip of the wing), causes a decrease in drag (most effective at high speeds) and an increase in lift.

Aspect ratio, taper ratio, and sweepback can be mixed to create different flying experiences. In Figure 4, you'll see some typical GA design configurations and their pros and cons.

Other wing designs, such as the elliptical and swept wing planforms, are observed on military aircraft, specifically the Supermarine *Spitfire* and the Dassault 3G.

5. Wing Pre- and Postflight Checklist

Preflight inspection is one of the most important steps you can take to ensure that your aircraft is fit for flight — and that includes inspection of your aircraft wings. Use this checklist as a guide in developing your own personalized system to inspect your wings before and after each and every flight. ➤

Wing Pre- and Postflight Checklist:

- Wing tips for cracks, loose or missing rivets; bolt security; general condition of wings and covering for torn fabric, bulges, wrinkles; aircraft at unimproved airports: prone to erosion on wing leading edges.
- Staining, dripping, puddles of fuel, oils anywhere on the wing or where a fuel tank is mounted, no matter the age of stains; rivet lines for fuel leakage on wet-wing fuel tanks.
- Wing strut attachment points for bows, bends; external bracing attachments and spar lines for distortion, cracks, security; internal brace fittings at wing attachment.
- Deicing: weeping wings, hot wings, inspect boots for leakage, attachment.
- Landing gear that retracts into wing, nacelle – clean, check frequently.
- Position lights on wingtips for operation right, left.
- Aileron, flap hinges, actuators for cleanliness, lubrication, dents, cracks, excess play, hinge pins, bolts for security, condition; movable surfaces for full freedom of movement includes full aileron, elevator, rudder deflection in all directions (which is often overlooked). In low-winged aircraft, bend/crouch to inspect under wings, flaps, ailerons.
- Aileron balance weights for cracks, security; lift up aileron to check security of the rivets holding balance weight in place.
- Pitot or pitot-static port(s), check drain holes for blockage, insects, water, never blow air into tube to clear; check both holes large (in front), small (in back) for blockage.
- Postflight: inspect under wings and other fuel tank locations for fuel stains.
- Post-storage: inspect for bird nests inside wings, control surfaces, and damage to rib stitching from mice.
- Winter: inspect wings, control surfaces for snow – it can melt and freeze inside controls.

Jennifer Caron is FAA *Safety Briefing's* copy editor and quality assurance lead. She is a certified technical writer-editor in aviation safety and flight standards.

GIVE ME A BRAKE ...

AND MAYBE A TIRE AND A STRUT TOO

Understanding Your Undercarriage

By Tom Hoffmann

While its value is sometimes overlooked and underestimated, your aircraft's landing gear is one of its hardest working parts. The stress of takeoffs and landings aside, your landing gear is also hard at work well after you have turned off the ignition and parked, supporting the weight of your airframe and powerplant around the clock. Let's take a closer look at this perpetually purposeful part to further appreciate its valiant role.

Keeping It Wheel

A typical GA aircraft landing gear uses three wheels: two main wheels and a third either on the nose (tricycle gear), or at the rear of the aircraft (conventional gear).

Most modern GA aircraft employ the tricycle gear configuration with a steerable nosewheel. A tricycle gear airplane allows for more forceful braking without the risk of nosing over, and it offers pilots better visibility during taxi, takeoff, and landing. Its forward center of gravity (CG) also provides more directional stability.

Conventional or tailwheel gear aircraft have a more rearward CG, so directional control is a little more daunting. A ground loop can occur if the heavier tail swerves around to get ahead of the main gear during ground operations. Ground loops can cause serious damage to aircraft and in some extreme cases, have resulted in fatalities. Another operational impediment is a tailwheel's limited forward visibility on or near the ground. These factors prompted the FAA to require specific training for a tailwheel endorsement. On the flip side, though, a tailwheel's nose up ground attitude has more room for a larger propeller. It is also better suited for backcountry operation on rough, unimproved fields. (In my personal, non-objective opinion, they also look pretty darn cool.)

Don't Steer Me Wrong

There are several different ways to steer an aircraft on the ground. Conventional gear aircraft with a free-moving tailwheel use just the rudder to steer, relying on airflow over the tail from the engine or forward motion. Taildraggers can also have steering linkage with the tailwheel in the cockpit, or rely on differential braking to turn the aircraft.

Tricycle gear aircraft typically rely on having a direct steering link to the nosewheel that is controlled by the rudder pedals, or a tiller on many larger aircraft. Although easier to operate, nosewheel steered aircraft are normally heavier and more prone to damage. They also have a tendency to shimmy during landing either from a worn shimmy damper, or insufficient back pressure to relieve weight off the nose.

Aircraft like the Cirrus SR22 or Diamond DA-20 use a castering (free-moving) nosewheel that requires differential braking to maneuver on the ground. This setup is generally lighter and easier to maintain, but can be a bit tricky in windy conditions. It can also wear brakes down faster. Intermittent toe taps can help with preventing brake damage or overheating.

Squeaky Clean, or Down and Dirty

We can further categorize landing gear into two main camps: fixed or retractable. Fixed gear aficionados tout simplicity and minimal maintenance — “the fewer the moving parts, the better.” Today’s composite materials along with aerodynamic wheel pants and fairings can reduce the parasite drag traditionally caused by a fixed gear.

Retractable gear tidies up the aircraft’s profile and offers greater aerodynamic efficiency and speed. It also provides more gliding range if the engine fails. However, that 15-20 knot gain in cruise speed may be offset by the increased weight of a retractable system, which includes hydraulic pumps and actuators. Remember too that a faster aircraft will have more parasite drag. If you’re considering a retractable gear aircraft, run the numbers to see if saving 20 minutes on your next airport diner dash is worth the weight and hassle. Hassle includes higher insurance and maintenance costs, as well as the greater potential for things to break down.

Strut Your Stuff

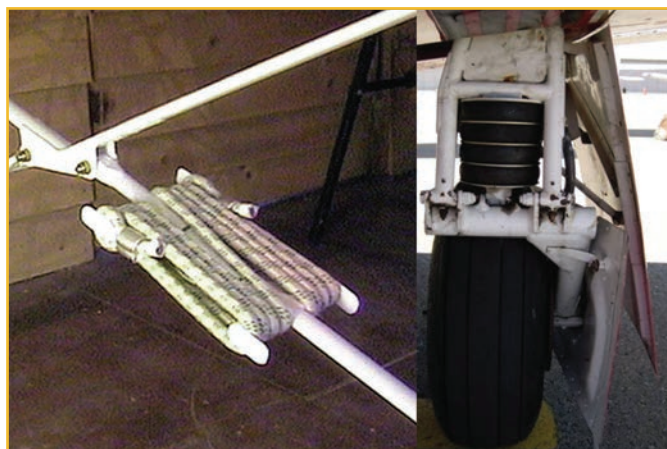
Now let’s look at the part that helps transfer the load of landing and supports the aircraft’s weight on the ground. This important job belongs to the landing gear struts, which absorb the shock of everything from a greaser to a teeth-rattling runway strike.

Early designs made use of a rigid strut that was welded directly to the airframe. While simple, the design meant that the impact of a hard landing was transferred directly to the airframe and its occupants with only inflatable tires helping to cushion some of the shock load. You’ll still see rigid struts on helicopters, which can easily absorb the shock from their typically low-impact landings.

More common to GA is the spring steel strut, which is designed to flex upward and outward and safely transfer the impact load of your aircraft during landing. They can be designed with their namesake spring steel, or with aluminum and composite materials. You’ll see this type of maintenance-free strut on the majority of single-engine Cessnas.

Another common strut design uses bungee cords to transfer landing loads. These elastic bungee cords are positioned between the airframe and the gear and must be regularly inspected. Piper Cubs are a popular example of this strut style.

A strut design that you’ll likely see on a large transport aircraft as well as several GA aircraft, is the shock or oleo-



Piper Cub bungee cord landing gear transfer landing loads to the airframe (top). Rubber, donut-type shock transfer is used on some Mooney aircraft (bottom).

pneumatic “oleo” strut. Similar in concept to automobile shock absorbers, oleo struts use compressed air or nitrogen with hydraulic fluid inside two telescoping cylinders to absorb the landing load. This mechanism essentially transfers the kinetic energy of the hydraulic fluid being pushed through an orifice into thermal energy and can handle much higher loads (with less recoil) than a spring steel design. Yay science! A metering pin or tube in the oleo strut also adjusts the fluid flow to permit a softer initial compression of the strut that becomes firmer as the opening is further restricted.

Many tricycle gear aircraft use an oleo strut in the nose-wheel, although it is by no means designed to bear the full weight of the aircraft. Its purpose is to smooth out the landing by reducing the recoil effect of the nose during touchdown.

Speaking of smooth landings, another gear variation with oleo struts is the trailing link gear, which uses a rear-facing L-shaped strut. In addition to the cushioning provided by the oleo strut, the L-shaped arm pivots to further help dissipate the upward energy of the touchdown.

According to pilot and aviation author William Dubois, whose Ercoupe uses this design, trailing link gear provides “buttery smooth Bob Hoover landings nearly every time.”

Dubois also appreciates the maintenance benefits, as the oleo strut is out in the open for easy access. If you do have oleo struts, know the acceptable static load extension of the strut (i.e., how much of the inner cylinder, or piston, is visible during preflight). For example, the Piper *Warrior* should generally have 3.25 inches of the piston showing on the nose and 4.5 inches for the main gear struts. If it is below limits or collapsed, the strut needs servicing. Also note that if the strut seems too bouncy, it might need some fluid. The appearance of excessive hydraulic fluid during inspection might be an indication of a leaky seal or O-ring.

Brake It Down

That leaves the final two parts of the landing gear: tires and brakes. Tires provide several important functions. They support the weight of the aircraft and provide shock absorption along with traction and braking when landing. Aircraft tires are among the strongest and hardest working pneumatic tires made, but proper maintenance and inspection is essential.

Tires are usually constructed of rubber compound for durability. They rely on diagonal layers of rubber-coated nylon cord fabric to provide strength. Unlike automobile tires, aircraft tires are designed to flex more, sometimes twice as much. This flexing allows better traction, but it also builds up heat much faster. That's why the hardest task for a tire is not necessarily that hard landing, but instead its ability to endure the rapid heat buildup from takeoffs and lengthy ground operations. The best safeguards against heat buildup include short ground rolls, slow taxi speeds, minimal braking, and proper inflation. Proper inflation assures the correct amount of flexing and keeps heat buildup to a minimum, increasing tire life and preventing excessive tread wear. When inspecting a tire for proper inflation, you

can easily tell if the air pressure has been consistently high or low. Excessive wear in the shoulder area is an indication of under-inflation, while wear in the center suggests over-inflation. Also be sure to check for cuts, cracks, bald spots, and adequate tread depth.

Airplane brakes can help with slowing down after landing, as well as maneuvering and tight turns on the ground. Most GA aircraft have disc brakes, which use fluid to compress a brake pad against a metal disc attached to the wheel. The brakes are operated with foot pedals that work independently to allow for differential braking. On every preflight, be sure to look for hydraulic fluid leaks and ensure proper brake pad thickness. Look for excessive corrosion too, especially if it's been some time since your last flight.

Getting It In Gear

So there you have it — landing gear 101. Although your undercarriage is sometimes underappreciated, hopefully this primer shines some new light on this hard working part of your plane. ➤

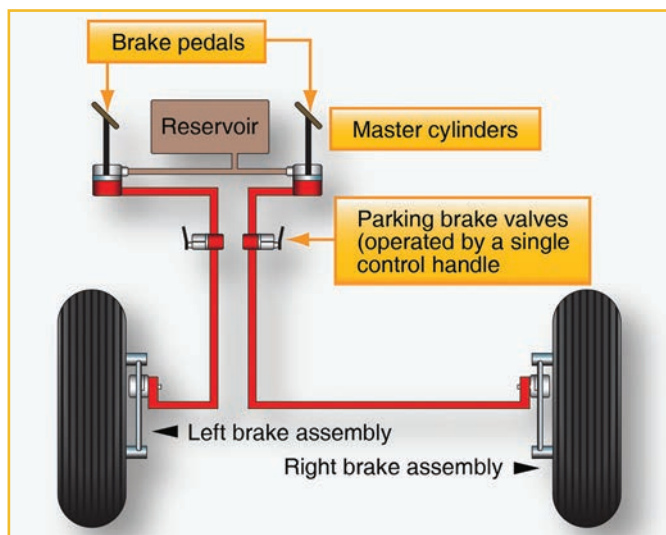
Tom Hoffmann is the managing editor of FAA Safety Briefing. He is a commercial pilot and holds an A&P certificate.

Did You Know?

Did you know that 14 CFR part 43 Appendix A includes several owner-performed preventive maintenance tasks related to landing gear? They include:

- Removal, installation, and repair of landing gear tires
- Replacing elastic shock absorber cords on landing gear
- Servicing landing gear shock struts by adding oil, air, or both
- Servicing landing gear wheel bearings, such as cleaning and greasing

Before doing any of these tasks, be sure you understand all facets of the work you plan to perform, and consider any and all applicable regulations. This includes making certain you have all available tools, equipment, and test apparatus necessary, as well as reference materials or manuals. Check out this issue's *Angle of Attack* department for more tips on owner-performed maintenance.



A remote reservoir services both master cylinders on some independent braking systems.

LEARN MORE

FAA Airframe Handbook, Chap. 13, Aircraft Landing Gear Systems
bit.ly/AircraftHandbooksChp13

HAND ME THE BOOK!

If I had to point to a single FAA resource that best aligns with the “Know Your Aircraft” theme of this issue of *FAA Safety Briefing* magazine, it would have to be the agency’s 2016 edition of FAA-H-8083-25B *Pilot’s Handbook of Aeronautical Knowledge* (PHAK). As with any of the FAA’s “H” series publications, you can download this one at no cost from the FAA’s website (see URL below).

To make it easier for you to match some of the content in this issue of the magazine to relevant parts of the PHAK, this column offers a guided tour of the matching chapters. For those reading an electronic version of this magazine, there are “VFR direct” links to those chapters.

Avionics

PHAK Chapter 8, Flight Instruments (PDF download)

The “No Surprises” article in this issue focuses on glass avionics and automation, but there are still plenty of airplanes around with the previously standard six-pack. If you fly such an airplane, you will find that this chapter starts with a comprehensive general review of principles of operation and function of the pitot-static instruments. For both actual and aspiring eAirplane (aka glass cockpit) pilots, the Electronic Flight Display presentation that follows offers a similar description of how the function of legacy pitot-static instruments is translated in common glass cockpit displays.

Next up is a discussion of gyroscopic flight instruments such as the turn coordinator and attitude indicator. For those with glass cockpits, the following discussion on the Attitude and Heading Reference System (AHRS) and, again, description of

how electronic flight instruments display gyro instrument functions, is well worth reviewing.

Next is a discussion and helpful review of angle of attack (AOA) indicators, whose presence and use in GA aircraft is expanding at a rapid rate.

Powerplants

PHAK Chapter 7, Aircraft Systems (PDF download)

This chapter of the PHAK offers a handy review of how reciprocating engines function, along with discussion of everything from propellers (fixed pitch, constant speed, overspeed), to the range of systems a good pilot ought to know about: induction (carburetor, fuel injection, turbochargers), oil, fuel, ignition, engine cooling, exhaust, and increasingly common full authority digital engine control (FADEC) systems.

For those who operate, or aspire to operate, turbine-powered aircraft, this chapter provides basic information on types of turbine engines and considerations for flying them properly (e.g., engine pressure ratio, exhaust gas temperature, etc.).

Given that this issue appears during the winter flying season, you might also find it helpful to review PHAK Chapter 7 information about anti-icing and de-icing systems. It bears repeating that for GA aircraft, even systems certified for flight into known icing conditions (FIKI) are intended to provide time for escaping such weather rather than for extended flight.

Fuselage, Empennage, Wings, Gear

PHAK Chapter 3 – Aircraft Construction (PDF download) and PHAK Chapter 7, Aircraft Systems (PDF download)

PHAK Chapters 3 and 7 look at aircraft construction and how the land-



ing gear operates. Chapter 3 reviews the basics of aircraft design, certification, and airworthiness, along with a description of the major aircraft components also discussed in some of this issue’s feature articles.

Of particular interest to those flying newer aircraft models is the information on composite aircraft construction. Important safety considerations in this area include issues such as fluid spills on composites and lightning strike protection.

There is, of course, much more in the PHAK. If you can’t be in your airplane as much during these winter months, this kind of review is a great way to be sure you’re ready for spring.

Susan Parson (susan.parson@faa.gov) is editor of *FAA Safety Briefing* and a Special Assistant in the FAA’s Flight Standards Service. She is a general aviation pilot and flight instructor.

LEARN MORE

FAA Pilot’s Handbook of Aeronautical Knowledge (PHAK) – FAA-H-8083-25B
[bit.ly/2nBxvNT](https://www.faa.gov/handbook/2nBxvNT)

Airman Testing
[bit.ly/31EMEgl](https://www.faa.gov/handbook/31EMEgl)



ON THE MONEY

Getting to Know Your Airplane as an Energy System

By Juan Merkt

“Without concepts there can be no thought, and without analogies there can be no concepts.”

— Douglas Hofstadter and Emmanuel Sander

Whether you realized it or not, the first time you increased back pressure on the elevator as you rotated the nose of your airplane for liftoff and left the ground without assistance from your instructor, you became an energy manager. Managing energy in the form of altitude and airspeed is a required skill for anyone who flies an airplane. Without it, you are more prone to bending one accidentally and even killing yourself in the process.

Learning to manage an airplane’s energy is critical for all new pilots. The Airman Certification Standards, or ACS, requires private pilot-airplane candidates to demonstrate understanding of energy management concepts. To help new pilots understand these concepts and put them into practice, I use an analogy everyone can relate to: money. This analogy is an excellent way to develop the correct mental model of the airplane as an *energy system*. This mental model will be the foundation to help you master managing your airplane’s energy safely and efficiently.

Manage Your Airplane’s Energy Wisely to Avoid Going Bankrupt

Like money, energy can be *earned*, *spent*, *saved*, *withdrawn*, and even *transferred* from one “account” to another.

Think of the airplane as the energy bank and the pilot as the owner of the bank accounts. The pilot/owner’s job is to manage energy transactions competently and to avoid becoming energy *bankrupt*. While running out of money is a bad thing, hitting the ground if you run out of altitude and airspeed energy could easily kill you.

Viewing the Airplane as an Energy System

Pilots control the airplane’s altitude and airspeed by managing its energy state. A flying airplane is an “open” energy system, which means that the airplane can gain energy from some source (e.g., the fuel tanks) and lose energy to the environment (e.g., the surrounding air). It also means that energy can be added to or removed from the airplane’s total mechanical energy — the total amount of energy stored as altitude (potential energy) and airspeed (kinetic energy).

Let’s expand the money analogy to help us understand the airplane as an energy system. An airplane has two savings accounts for storing mechanical energy. One account stores energy as altitude and the other one as airspeed (Figure 1). Once airborne, the airplane earns energy from engine thrust (T), or income. It spends energy on aerodynamic drag (D), which is an expense (Figure 1). The difference between energy earned and spent ($T - D$) is the net income, which determines whether total mechanical energy — the savings — increases, decreases, or remains the same. At any given time, the energy state of the airplane is determined by the total amount and distribution of energy saved as altitude and airspeed.

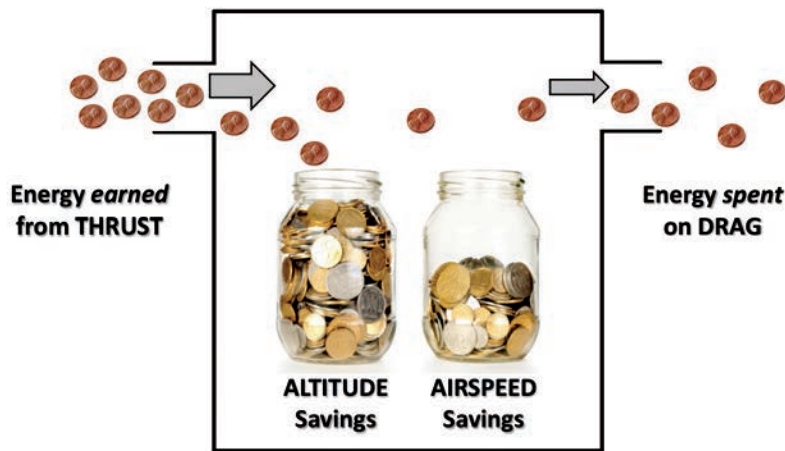


Figure 1

When energy income exceeds the amount needed to pay for drag ($T - D > 0$), the pilot can deposit the surplus energy and save it as increased altitude or airspeed. For example, if the pilot decides to put all the surplus energy into the altitude account, the airplane can climb at a constant airspeed (Figure 2A). But if the pilot opts to place all the surplus energy into the airspeed account, the airplane can accelerate while maintaining altitude (Figure 2B).

When the airplane does not have enough energy income to pay for drag ($T - D < 0$), then the pilot must dip into the savings accounts. For example, the pilot may choose to let the airplane descend at a constant airspeed (Figure 2C) or

slow down while maintaining altitude (Figure 2D) as energy is withdrawn out of one of the savings accounts to help pay for drag. When energy gained equals that spent ($T - D = 0$), all thrust is spent on drag. Nothing is added or removed from the savings accounts. In this case, the total amount of mechanical energy and its distribution over altitude and airspeed does not change. Both remain constant as the airplane maintains a constant altitude and airspeed (Figure 2E).

Also like money, energy can be transferred from one savings account to the other by exchanging the energy between altitude and airspeed. For example, when you trade airspeed for altitude, you will notice that as altitude increases, airspeed decreases. In other words, when energy is exchanged, altitude and airspeed always change in opposite directions (absent any other energy or control inputs). As one goes up, the other one must come down. Also note that even though the distribution of energy over altitude and airspeed may change dramatically during energy exchange, the total amount of mechanical energy remains the same in the short term (Figure 2F). In the long term, thrust would need to be adjusted to match drag as the latter varies with changes in airspeed.

Like Managing Money, Managing Energy is a Balancing Act

Since the airplane gains energy from engine thrust (T) and loses energy through aerodynamic drag (D), energy

Energy Transaction Examples		Net Income ($T - D$)	Savings Accounts Altitude Airspeed		Change in Energy State
A		> 0	Increase	No change	Climb at constant airspeed
B		> 0	No change	Increase	Acceleration at constant altitude
C		< 0	Decrease	No change	Descent at constant airspeed
D		< 0	No change	Decrease	Deceleration at constant altitude
E		$= 0$	No change	No change	Constant altitude and airspeed (no change)
F		$= 0$	Increase	Decrease	Climb and deceleration

Figure 2A-F

A FRAME OF REFERENCE FOR MANAGING ENERGY STATE

To manage the airplane's energy state, we need a frame of reference for tracking altitude and speed that is *independent* of varying terrain elevation and wind conditions. Luckily, we already have such a reference system. The *indicated* altitude displayed in the altimeter and its associated potential energy are based on the height of the airplane above a *fixed* reference point (mean sea level or MSL), not on the height above ground level (AGL), which changes with variations in terrain elevation. Likewise, the *indicated* airspeed displayed in the airspeed indicator and its associated kinetic energy are based on the speed of the airplane relative to the air, not on the speed relative to the ground below which varies with changes in wind speed and direction. This terrain/wind-independent frame of reference is essential for managing energy state, whether the airplane is maintaining a constant indicated altitude and airspeed, or whether it is climbing, descending, accelerating, or decelerating. Note that changes in indicated altitude and airspeed are attained through forces resulting from the pilot's direct manipulation of the controls. These "internal" factors determine the airplane's ability to climb/descend or accelerate/decelerate. In contrast, AGL-altitude and groundspeed are dependent on "external" factors, terrain elevation and wind condition, that change independent of pilot input. Of course, the pilot can manipulate the airplane's energy in such a way as to minimize any risks associated with terrain or wind. Using the money analogy, you can think of a tailwind as a "dividend" and a headwind as a "tax" on groundspeed. Likewise, you can view descending terrain as a "dividend" and rising terrain as a "tax" on AGL-altitude. For example, the pilot may seek to manipulate energy state so as to maximize the airplane's energy gains and minimize energy losses when faced, for example, with increasing terrain taxes.

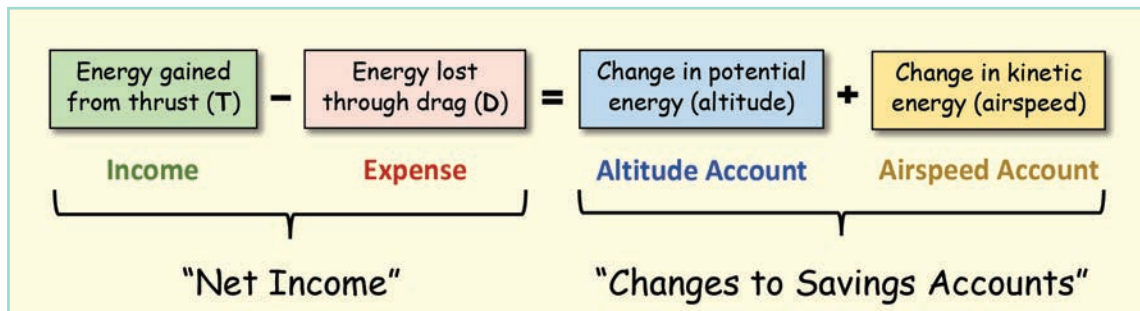


Figure 3

flows continuously into and out of the airplane while in flight. Usually measured as specific excess power (P_s), or energy rate of change, the energy flow is a direct function of the difference between thrust and drag ($T - D$). More importantly, there is a fundamental relationship between changes in the airplane's total energy resulting from this energy flow on one hand, and changes in the energy stored as altitude and airspeed on the other. This fundamental relationship can be summarized through the airplane's energy balance equation (Figure 3).

If energy were money, the left side of the energy balance equation would represent the airplane's "net income," while the right side would reflect matching changes to the airplane's "savings accounts" (Figure 3). Thus, the left side controls changes to the airplane's total energy, while the right side regulates the distribution of the resulting change in energy over altitude and airspeed.

Because energy cannot be created or destroyed, a change in total energy resulting from the difference between thrust and drag (left side) always matches the change in total energy redistributed over altitude and airspeed (right side). Although the energy rate of change varies during flight — becoming positive, negative, or zero — both sides of the

equation are inexorably balanced regardless of whether the airplane is accelerating, decelerating, climbing, descending, or maintaining constant altitude and airspeed. (Note: This simplified balance equation does not account for long-term changes in total mechanical energy caused by the reduction in aircraft weight as fuel is gradually burned in flight. Although the effect of weight loss on total energy becomes critical when solving long-term aircraft performance problems of range and endurance, it is negligible when considering short-term flight control problems.)

Of course, the pilot controls the change in total energy on the left side of the equation, as well as the distribution of any changes in energy over altitude and airspeed on the right side. How the pilot coordinates the throttle and elevator to achieve and maintain desired altitude and airspeed targets, as well as avoid energy "crises" and "bankruptcies," is at the core of energy management and would be a topic for another time. >

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CHECK YOURSELF BEFORE YOU WRECK YOURSELF



Some things change and some things stay the same. When it comes to basic things like blenders and bicycles, you can be reasonably certain that you will be able to use even the newest and most technologically advanced versions of these products because the concepts are relatively simple. However, when it comes to things like smart phones and drones, you're going to be left behind if you don't keep up with the technology and stay versatile. To be more specific, when it comes to drones, you might wind up losing your drone or worse, hurting yourself or someone else.

It seems like everything today is "smart" and customizable. This fact offers lots of options but also demands lots of responsibility for the choices we make. There is an amazing variety of consumer drones on the shelves today. Some are pretty basic and easy to fly, while others are highly capable machines with advanced functions like first person view and automated flight. It would be nearly impossible to provide a basic "how to" guide for understanding and operating any drone. But, there is a simple checklist you can use to help guide your choices and your flight plans. It's called "Check3 GPS."

Check3 GPS (Gear, Plan, Skills) is a quick and easy checklist that you can use before and during flight to help you think through all of the possible hazards you might face and how you'll handle them. The military has adopted this idea, which is also supported by the Unmanned Aircraft Safety Team (UAST). In fact, it has been widely used for all sorts of activities from snowboarding to free diving — and it works great for flying drones too.

Here's how it can work for you:

Gear: *Don't Blame the Equipment.*

Learn all about what your drone can do and how it works. The best way to do this is to read the owner's manual and talk to other people who fly the same equipment. But gear isn't just the machine. You'll also want to routinely check that you have the most up-to-date software and that all of the components are in good working order. Additionally, you'll want to think about other gear you might need for a given flight like glare shields, camera lenses, or backup power sources.

Plan: *Plan your work and work your plan.* Good planning usually leads to good outcomes. It always pays to think ahead about where, when, and how you're going to execute a flight. This includes things like: time of day (when is sunrise/sunset?), weather (is there rain or are there high winds in the forecast?), location (will there be people around or are you near an airport?), airspace (do you need an authorization?), temporary flight restrictions (check to make sure there aren't any), route (what pattern and altitude will you use?), contingency plan (what will you do if things don't go according to plan?). You can (and should) add appropriate considerations to this list.

Skills: *Garbage in, garbage out.*

It's tempting to underappreciate the skills involved in flying a drone. Many drones are marketed as "easy to fly" or "flies itself," but no matter how advanced your equipment, it still requires a proficient person at the controls. This means that you should learn about and practice with your drone's different functions in a safe and open area before flying in more complicated places. It also means that you should take care of yourself — be sure to eat, sleep, and avoid medications that might affect your ability to make good decisions. You should always double check your plan. Many accidents and incidents result from a mistaken input into a flight program. The difference between flying at 308 feet versus 380 feet may not seem like a big deal ... unless there's a 310 foot tree in your flight path.

Check3 GPS works just as well for beginners as it does for the pros. So always Check3 before you fly.

Danielle Corbett is an aviation safety inspector with the FAA's Office of Unmanned Aircraft Systems.



LEARN MORE

Check3 GPS
www.Check3GPS.com



REDUCING MAINTENANCE RELATED ENGINE FAILURES

What Mechanics Can Do

When you look at the 1,381 fatal general aviation accidents from 2008-2015, 6.9-percent were attributed to engine maintenance-related failures. This number is low, but we can do better. Here are five best practices to incorporate during your next inspection to reduce maintenance-related engine failures.

Step 1: Research

A conformity inspection is used to determine that completed production products and related parts conform to the approved type design and are in a condition for safe operation. Before a conformity inspection is performed, look at the logbooks to determine what kind of inspection program the aircraft is on. Ask the owner/operator about anomalies or unusual trends. Next, review for part and serial numbers, total time, and time since service and overhaul. Check for installed supplemental type certificates (STCs), major repairs, alterations, and obtain applicable TC data sheet specifications, 337s, instructions for continued airworthiness (ICA), airworthiness directives (ADs), manufacturer's service info, and service difficulty reports.

Step 2: Plan

Plan how and what you are going to conform so as to make sure the inspection runs smoothly and efficiently in the context of other demands on your shop. Get the regulatory inspection checklist, and include ICAs. Remember, when you're using 14 CFR appendix D, the items to be included in annual and 100-hour inspections may not be all inclusive for the aircraft you are working on. The manufacturer's checklist is a good place to check items. Next, get

CHECKLISTS ARE ESSENTIAL TOOLS THAT CAN HELP PREVENT OVERLOOKING PROCEDURES AND/OR ITEMS OF INSPECTION.

the pre- and post-inspection run-up checklist, the required/special inspection tools, and technical data. Finally, review the FAA Safety Team's "Before the Task" Checklist at bit.ly/3488mLR.

Step 3: Conform

Installed components must match the records and 337s, so ensure that they're eligible for installation and conform to approved data. Verify the status of ADs, weight and balance records, placards, instrument markings, and check for undocumented repairs and alterations.

Step 4: Perform the Inspection

First, complete the performance runs. Don't overlook this step, as it provides a baseline for comparison with the post-inspection run. Remember, any inspection is a process to find deficiencies that need to be corrected prior to return to service. Next, protect removed parts, comply with ADs, document discrepancies, follow the inspection checklist, and make sure to account for any tools so none are left in the aircraft. Conduct a detailed work flow/shift change briefing, if needed.

Step 5: Return to Service

After all required maintenance is performed and all discrepancies are addressed, complete and document

post-inspection performance runs. Per 14 CFR section 43.15, you are required to run the aircraft after an annual, 100-hour, or progressive inspection. This often overlooked area contributes to engine power loss, so be sure it is properly performed to prevent any maintenance-related engine power loss. It's also very important to perform proper (i.e., careful) leak checks. Next, make legible and complete record entries with times and/or cycles, and submit malfunction and defect reports. Finally, review the FAA Safety Team's "After the Task" Checklist at bit.ly/3488mLR.

Checklists are essential tools that can help prevent overlooking procedures and/or items of inspection. Double-checking your work and having another appropriately-rated individual review it are also best practices.

Remember — post maintenance checks are to be performed after *any* type of maintenance and *before* the use of the aircraft. It's an important step to prevent engine power loss, determine satisfactory performance with the manufacturer's requirements, make sure the aircraft operates properly, and that it develops the recommended power after maintenance.

You know that the pilot makes the final airworthiness determination, but it is *your* responsibility, when approving for return to service, that the work you have done is in an airworthy condition.

LEARN MORE

Reducing Maintenance Related Engine Failures course (ALC-457)
www.FAASafety.gov

OWNER-PERFORMED PREVENTIVE MAINTENANCE



What better way to know your aircraft than to pull out that tool box, peel back those cowlings, and perform some preventive maintenance? Pilots who perform preventive maintenance reap the benefits of knowing more about the inner workings of engines and airframes, as well as all their associated systems and components (many of which are discussed throughout this issue). In addition, AMTs can better communicate with these pilots because their improved technical know-how enables them to help diagnose difficulties.

One of the best ways to prepare for your first foray into aviation maintenance is to understand the basics. This “Know Your Aircraft” issue is a start, but dust off those pilot handbooks and manuals for a good refresher on aircraft engines, propellers, electrical systems, landing gear, and more. You can also track down the maintenance manuals for your specific aircraft and examine diagrams and procedures in detail. If you are changing spark plugs or oil filters, you need to understand the systems these components impact.

So exactly what kind of maintenance can you legally perform on your aircraft? If you hold at least a private pilot certificate issued under Title 14 Code of Federal Regulations (14 CFR)

part 61 and your aircraft is not used under 14 CFR parts 121, 129, or 135, you may perform preventive maintenance on your own aircraft. To see a list of the 31 items a pilot can perform without supervision, see Appendix A in 14 CFR part 43 (bit.ly/43AppA). Examples include:

- Removal, installation, and repair of landing-gear tires
- Replacing or cleaning spark plugs and setting of spark plug gap clearance
- Replacement/adjustment of non-structural standard fasteners incidental to operations

Before you start changing tires, be sure you understand an often overlooked detail that can affect your eligibility to perform these tasks. 14 CFR section 1.1 defines preventive maintenance as “... simple or minor preservation operations and the replacement of small standard parts not involving complex assembly operations.” The key word here is *complex*.

Due to differences in aircraft design and accessibility of certain components, a procedure like changing an oil filter may be a simple job on some aircraft, but complex on others. Owners and pilots must use good judgment in determining whether a specific function appropriately qualifies as preventive maintenance. When in doubt, talk to a mechanic.

Be sure you also understand all facets of the work you plan to perform, along with careful attention to all applicable regulations. Pilots performing preventive maintenance are bound by the same regulations as any certificated AMT. This includes making certain you have all available tools, equipment, and test appara-

tus necessary for any maintenance task. You’ll also need all associated reference materials and manuals. In particular, 14 CFR section 43.13(a) states that each person performing maintenance — pilot or mechanic — is required to use “the methods, techniques, and practices prescribed in the current manufacturer’s maintenance manuals ... or data acceptable to the Administrator.”

This is important; glossing over something like prescribed torque values can have deadly consequences. Tighter does not always mean better! Finally, if the job seems the least bit complicated, or includes any step that is beyond your ability, put down the tool, step away, and seek help. Have someone who knows the task well walk you through the steps.

Performing maintenance on your aircraft can have several important benefits. It can save time, money, and can open doors to a new level of understanding your aircraft. But along with this new knowledge comes responsibilities. With good practices, the proper tools and materials, and a professional attitude, you’ll be sure to “maintain” your way to greater safety.

Tom Hoffmann is the managing editor of *FAA Safety Briefing*. He is a commercial pilot and holds an A&P certificate.

LEARN MORE

Advisory Circular (AC) 43-12A, *Preventive Maintenance*
bit.ly/AC43-12

FAA Safety Briefing, Mar/Apr 2010,
“Maintaining Your Way to Greater Safety”
bit.ly/2oLZoEy



HELICOPTER PREFLIGHTS – WORTH A CLOSER LOOK

Is the helicopter preflight absolutely necessary? What's the worst thing that can happen if I skip it? I believe the best way to answer these questions is by asking why we are still having accidents and fatalities due to incomplete or omitted preflights. Unfortunately, some pilots take the approach of, "Yep ... it's a helicopter. Preflight complete!"

The United States Helicopter Safety Team (USHST) validated the importance of the preflight in its accident analysis work. The USHST is a team of industry and U.S. government participants who are driven to improve U.S. civil helicopter safety. The team has analyzed thousands of accidents over the last decade. Its most recent work on fatal accidents from 2009 – 2013 found cases where the fatal outcome was the result of the helicopter pilot not taking the preflight requirement seriously. NTSB records show a similar trend. A recent query of its aviation accident database returned 36 events that identified errors with preflight inspection. Sadly, three of these accidents were fatal. The NTSB probable cause statements read, "the pilot's inadequate preflight inspection that failed to detect ..." These cases are serious failures within the aviation industry and they show how a lack of professionalism can bring harm to people and result in damage to the helicopter.

Based upon this analysis, the USHST developed Helicopter Safety Enhancement (H-SE) #28 called "Helicopter Final Walk Around/Security of External Cargo." A few highlights of the H-SE:

- Follow the manufacturer's suggested outline for both the inside and outside inspection. This ensures check-



ing all the items the manufacturer deems important. If supplemental equipment has been added to the helicopter, these procedures should be included on the checklist as well.

- Enforce a "no phone" policy during preflight inspections.
- Ensure pilot/pilots have adequate time for pre-mission planning and preflight inspections. Do not rush anything.

The FAA's *Helicopter Flying Handbook* thoroughly explains the importance of conducting a preflight inspection in Chapter 8, *Ground Procedures and Flight Preparations*. The added importance of a preflight is magnified when accomplishing a post-maintenance check flight. In these cases, consider completing the preflight with a maintenance representative. Open *all* panels and inspect the systems with a deliberate methodology: "See it, touch it, and speak it!" Ensuring the proper torque stripes and security of all safety critical hardware should be of the highest importance. A best practice is to perform the maintenance preflight in the reverse order to help the pilot see the aircraft from a different perspective.

To further appreciate the importance of the preflight, reflect on the following real world example. How likely is it that several aviation safety professionals could leave a wrench on a rotor system? Could this happen to you? The wrench in the photo was missed on the post maintenance inspections, as well as the maintenance and pilot preflights. It was flown

back to the operator's field before being discovered. Most likely the preflight was performed from the ground rather than climbing on top of the aircraft. The preflight check for this particular model calls for visual inspection of the main rotor head. This error could have easily had a tragic outcome. This is an obvious case of confirmation bias — you expect to see exactly what you have seen hundreds of times before and sometimes miss the obvious.

A few more suggestions: If you experience a disruption or distraction while performing your preflight, go back to the last section completed in full. Consider performing your preflight with your checklist in hand, performing every item with great attention to detail. This includes a review of the aircraft registration, airworthiness certificate, operating limitations (POH or placard) and the most current weight and balance. Together, these measures ensure a complete and quality preflight.

Scott Tyrrell is a continued operational safety specialist/accident investigator with the FAA's Aircraft Certification Service.



Here's feedback from some members of our new GA Safety Facebook Group!

[Facebook.com/groups/GASafety](https://www.facebook.com/groups/GASafety)

If you're not a member, we encourage you to join in on the discussions and post relevant GA content that makes the National Airspace System (NAS) safer.

When in Doubt, Rip it Out!

Attention all balloonists — if a power line strike is imminent, the safest decision is to turn off all fuel, bleed all remaining fuel from the lines, and “rip out” (e.g., open wide) the deflation port. Learn more balloon safety tips at: adobe.ly/32pHHZV.

Thank you, FAA Safety Briefing Magazine for entrusting us to share ballooning knowledge in your Sep/Oct 2019 issue! We are proud to be a FAA Safety Team (FAASafetyTeam) training provider and representative.

— The Balloon Training Academy

Always Conduct an Advanced Preflight After Maintenance

As the final authority for your aircraft's fitness for flight, it's important that you know how to

properly preflight your aircraft after maintenance. For tips, check out our #FlySafe fact sheet at: bit.ly/MxPreflight.

Here's a hint: if you're a renter, and not involved in the maintenance of the aircraft you rent to fly (students and a large percentage of private pilots), every preflight should be an “advanced preflight.”

— Ken

Exactly! Not everybody knows a good preflight.

— Terry

Glad for Gladwell

Hello Susan,
This is to compliment you on this terrific article [Uncommon Sensing] in the recent FAA Safety Briefing Sep/Oct 2019 edition. I read it several times in-depth, and Mr. M. Gladwell is a fine author, I agree. Too many of these aspects of human everyday norms and our behavior affect our flying skills more and the reinforcement is always necessary.

As an inactive flight instructor, these articles all prove imperative to keep me abreast and immersed and continually learning! I hope you and the team continue the awesome work for us GA pilots out there like myself.

— Niven

Thanks so much for the feedback. Our team cares a lot about providing useful information to our fellow pilots, and it's nice to know when we hit the mark!

Nice also to meet a fellow Gladwell aficionado. While we are on the subject of books, I highly recommend Mark Vanhoenacker's “Skyfaring.” It's a well-written book about the beauty of aviation, and I always recommend it to my fellow pilots.

Loving the Live

I just watched the latest FAA Safety Briefing Live and read the latest magazine. I wanted to write a quick note saying thank you! It was fantastic!

I read Adam Magee's article on ballooning in the Nov/Dec 2018 issue of FAA Safety Briefing too, and I also enjoyed his article in the Sep/Oct 2019 issue about the dangers of power lines.

— Steve

Thanks for your day-brightening note. We, along with our FAA Safety Briefing Live co-host Paul Preidecker, and John Teipen the magician who makes FAASB Live work, all appreciate your taking the time to let us know that you found it helpful. We also enjoy having Adam as a guest writer, and it's good to know that his articles are useful tools to help improve education amongst the lighter-than-air community.



Federal Aviation
Administration

— ADS-B —

Privacy ICAO Address

To address privacy concerns, the FAA has initiated the Privacy ICAO Address (PIA) program to improve the privacy of the following eligible aircraft:

- ☒ U.S. registered
- ☒ 1090 MHz ADS-B equipped
- ☒ Using a third-party call sign
- ☒ Flying in domestic U.S. airspace

The PIA program will enable interested aircraft owners to request an alternate, temporary ICAO Aircraft Address, which will not be assigned to the owner in the Civil Aviation Registry (CAR).

For more details and information, visit www.faa.gov/go/adsbprivacy

Let us hear from you! Send your comments, suggestions, and questions to SafetyBriefing@faa.gov. You can also reach us on Twitter @FAASafetyBrief or on Facebook at [facebook.com/FAA](https://www.facebook.com/FAA). We may edit letters for style and/or length. Due to our publishing schedule, responses may not appear for several issues. While we do not print anonymous letters, we will withhold names or send personal replies upon request. If you have a concern with an immediate FAA operational issue, contact your local Flight Standards Office or air traffic facility.



WISHING WASHES OUT

Either you deal with what is the reality, or you can be sure that the reality is going to deal with you.

— Alex Haley

“But Susan, it’s not supposed to do *that*. It’s supposed to . . .” The left-seat pilot and owner of the airplane then proceeded to tell me, in impressive and impassioned detail, how the autopilot was supposed to capture the approach course set into the freshly installed moving map navigator and track it smoothly down the glideslope to decision altitude. He had hired me to ride along that day, first to conduct an instrument proficiency check and then to help figure out why the new equipment wasn’t behaving as expected.

STOP FIXATING ON WHAT YOU WANT IT TO DO, OR WHAT IT IS “SUPPOSED” TO DO. FIGURE OUT WHAT THE EQUIPMENT DOES DO ON A CONSISTENT BASIS AND ADJUST YOUR EXPECTATIONS AND YOUR ACTIONS TO MATCH.

I had been watching carefully. I had no doubt the pilot was doing everything right in terms of programming the equipment, which I knew well from experience in other airplanes. But repeated approaches at the same airport followed by similar attempts elsewhere produced the same undesired result. It was increasingly clear to me that the two electronic siblings in

the panel weren’t getting along. We were witnessing the squabble resulting from an older autopilot that simply couldn’t, or wouldn’t, take instructions from the upstart navigation newcomer.

I subsequently consulted an FAA pilot colleague who also happens to be an avionics engineer. He confirmed my theory that my pilot friend’s problem was akin to the issue most of us have experienced with desktop computers and other electronic devices: new gadgets and new software don’t always work well on older platforms. The best help I could offer my pilot friend was to follow the advice that author Alex Haley so deftly offers in the quote above: Accept reality. Stop fixating on what you want it to do, or what it is “supposed” to do. Figure out what the equipment *does* do on a consistent basis and adjust your expectations and your actions to match.

Reality Rules

Haley’s advice is certainly in line with the know-your-airplane theme of this issue, and I have shared this concept with lots of “Frankenplane” owners and pilots. As my flying club discovered when we made a relatively simple upgrade a few years ago — installing an ADS-B transponder — the process of integrating the new item was not all that simple. First, the installer had to do some United Nations-style translation and mediation just to enable basic gadget communication and peaceful co-existence. But then the members of the club had to get acquainted and comfortable with the way our new equipment performed old functions. It was helpful to read the instructions — something we



Photo courtesy of Garmin.

humans are oddly reluctant to do — but probably none of us really “knew” the airplane as it was now configured until we had logged a few actual flying hours with the new box. I would add that, since a fully functional transponder is absolutely critical in the Washington DC Special Flight Rules Area, we had ample incentive to ensure that we really did know how it works.

The rationale for this issue’s know-your-airplane focus goes way beyond new equipment, of course. We are all familiar with stories of pilots who averted engine or electrical failures because they knew what “normal” indications are, monitored carefully enough to spot something in the not-quite-right category and — a critical step — accepted and acted on those indications. Also familiar are the stories of how those critical seconds of “this-can’t-be-happening” disbelief can paralyze a pilot facing mechanical malfunction.

As Malcolm Gladwell, a favorite author of mine, observes in his new book *Talking to Strangers*, humans have an astonishing capacity to filter and rationalize inconvenient facts so we can accept something we want to believe is true. Just don’t let that habit follow you behind the controls of an airplane!

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DR. BRETT WYRICK

Deputy Federal Air Surgeon

Editor's note: *In this "know your aircraft" issue, we thought it was equally important to "know yourself" too, especially when it comes to personal medical issues and limitations. As the new deputy federal air surgeon, Dr. Wyrick will be instrumental in developing aeromedical certification policy and regulations that help you determine fitness for flight.*

For newly appointed Deputy Federal Air Surgeon Dr. Brett Wyrick, an affinity for aviation began early on and was most definitely a family affair. His uncles flew wartime combat missions (one flew B-24 bombers in WWII and another flew F-105 "Thuds" in Vietnam). Dr. Wyrick's father was a decorated F-100 pilot, earning the Distinguished Flying Cross for Valor while flying 352 combat missions in Southeast Asia.

Brett Wyrick was born and raised at Luke Air Force Base in Glendale, Ariz., but moved with his family from one air base to another across the southwest. Throughout his childhood, he recalls the excitement of hearing constant supersonic jet activity overhead. "I remember many from the Greatest Generation who were still serving in the Air Force with my Dad, as well as those of the next generation, some of whom would fly to the moon with Project Apollo." He dreamed of the day he too would fly jets.

That pilot career priority changed one fateful day at age 14. While waiting at the airport on an especially hot day for his grandparents to arrive on a flight into Montgomery, Ala., an elderly woman standing nearby collapsed by the outdoor baggage claim. Brett sprang into action and began performing CPR as he was taught in the Boy Scouts. Unfortunately, the

woman died, but he vowed from that day forward to become a physician so he could help people in life-threatening situations.

Two decades later, he became a trauma surgeon attending to badly injured and burned patients. However, the itch to fly and serve in the military was still there, so he joined the Air National Guard as a flight surgeon. While finishing his surgical residency in Oklahoma, Dr. Wyrick finally pursued his supersonic dreams by flying in the backseat of F-16s, and later flying F-15s with the Hawaii Guard, after he opened his practice in Hilo, Hawaii. After several deployments to Iraq, Kosovo, and Afghanistan, Wyrick decided to close his practice to go on active duty with the U.S. Air Force for ten years.

During a deployment to Afghanistan in 2015, then Colonel Wyrick, began exploring post-military career options. After spotting an FAA job vacancy for the Northwest Mountain Regional Flight Surgeon, he interviewed via Skype from Bagram Air Base. His job offer came conditioned on his ability to "come home alive one more time." Before he could take the position, Wyrick was seriously injured and had to be airlifted to Landstuhl Military Medical Center in Germany for surgery and treatment. The Federal Air Surgeon held his new job for him during his recovery which, as Wyrick



notes, was an "awesome start in a wonderful organization."

Dr. Wyrick is proud that the FAA's Office of Aerospace Medicine is on the cutting edge of human performance in aviation and space. "The rest of the world looks to us and follows our lead," says Wyrick. "We seek new and innovative ways to keep pilots in the cockpit, and nothing gives us greater pleasure than helping to get someone back to flying after injury or illness." He points to the new insulin-treated diabetes mellitus policy as evidence of this forward thinking mentality, which leverages new technology and data to help more airmen qualify.

"We're still only scratching the surface," says Wyrick. "Many good things will be coming out of the Office of Aerospace Medicine in the next few years as we do our part to enhance safety in the National Air Space, and I am thrilled to be a part of it."

MANY GOOD THINGS WILL BE COMING OUT OF THE OFFICE OF AEROSPACE MEDICINE IN THE NEXT FEW YEARS AS WE DO OUR PART TO ENHANCE SAFETY IN THE NATIONAL AIR SPACE, AND I AM THRILLED TO BE A PART OF IT.



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– MayCay Beeler – pilot, author,
and award-winning TV personality

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