



The DC Designs Mini-Guide to aviation, for newcomers to Microsoft Flight Simulator

By Dean Crawford, the owner and founder of DC Designs.

Facebook: <https://www.facebook.com/DCDesignsAircraft>

YouTube: <https://www.youtube.com/user/DEAN01973/videos>

Discord: <https://discord.gg/KAUJqMRvFU>

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

“The F-15 Eagle should go 1,400 knots! I can’t get more than 1,000 knots even in a steep dive!”

“The wings on the F-14 Tomcat should sweep by 300 knots indicated. They don’t move until 500 knots. This is inaccurate!”

“Concorde won’t reach Mach 2! It climbs for a while, then stalls and crashes!”

“Microsoft Flight Simulator is just a ‘scenery simulator’ made to look pretty, it’s not realistic in any way. <Insert favourite simulator > is much more realistic!”

“My F-15 Eagle weighed 60,000lbs, and the engines produce only 40,000lbs of thrust in full afterburner, yet I went into a level max-G turn and the Eagle accelerated! It obviously should have slowed down due to the extra drag!”

“MSFS airplanes are not study-level! It’s a game, not a simulator!”

“The flight model feels ‘off’ after the latest update, it was fine before.”

“Military aircraft should not be allowed in Microsoft Flight Simulator. It’s for civilian aircraft only.”

The above are an example of comments made about aircraft by DC Designs, about Microsoft Flight Simulator, and about aircraft by other developers. They are all incorrect. This document is designed to be as short as possible, and yet explain *as much as possible* to those who wish to learn a little about real aviation, and how it relates to Microsoft Flight Simulator, before using aircraft for PC or Xbox console. Please read the next line *very carefully* and remember it as you read on:

AVIATION IS A VAST AND COMPLEX SUBJECT

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

Across the many forums and chat rooms available on the Internet, you will find yourself stunned to discover that the flight simulation world is apparently populated with millions of experts in everything from aerodynamics, fluid dynamics, meteorology, engineering and, of course, the professional flying of both commercial and military aircraft, all of whom are keen to share their deep understanding of all the above. Isn't it strange though that in real life, pilots and aeronautical engineers seem quite rare?

The reality, of course, is that they *are* quite rare.

It's hard to pin down precise numbers but in the average country, less than 1% of the population hold a Private Pilot's License (I'm fortunate enough to be one of these, although I let mine lapse some years ago in favour of Virtual Reality). Less than 0.1% hold an Airline Transport Pilot's Licence. Less than 0.01% are military / fighter pilots. Just have a think about that for a moment; maybe 1% of the population hold a professional aviation or aeronautical engineering qualification. There is a very good reason for this. *Being a professional pilot or aeronautical engineer is hard and complex work.*

The reality is that the vast majority of people commenting on aerodynamics in flight simulation on the Internet simply don't have the required experience to do so. It's not that they're incapable of understanding it. It's just that aviation is a vast subject that requires a great deal of study, and few people have the time to learn about it when it's not their full-time job. Most people just want to fly their favourite airplane in Microsoft Flight Simulator. Ask any real pilot, even one with decades of experience and thousands of hours on their log book, if they know "everything" about aviation and they'll laugh, because nobody on earth knows "everything" about aviation.

So, forget about most comments you have ever read about this subject on YouTube, Facebook, your local flight simulation forum etc. Let's get one of those quotes I listed at the top of the document out of the way first, just so we're a little bit clearer on what Microsoft Flight Simulator really represents.

"Microsoft Flight Simulator is just a 'scenery simulator' that looks pretty, it's not realistic in any way. I use <Insert favourite simulator > and it's much more realistic!"

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

This sort of comment has been bandied about from the moment MSFS was released, and usually comes from fans of other simulators who feel threatened by MSFS and decide, quite often without even trying it, that MSFS is just about being pretty and nothing else. Nothing could be further from the truth.

The reason that MSFS looks as good as it does is because Asobo Studios, the company that built the simulator for Microsoft, went to such incredible lengths to model our planet accurately that it ended up looking as beautiful as our planet does. The atmospheric and meteorological elements of MSFS are *light-years ahead* of any other desktop simulator. Precipitation, temperature inversions, air pollution, rain shafts, turbulence, thermals and rainbows appear not because they are programmed to randomly appear, but because the atmosphere within the simulator mimics our own real planet's atmosphere so closely that they therefore appear under the same conditions as they would in real life.

This is important for many reasons (I often consider MSFS to be as much a planet-simulator as a flight simulator) but mainly because most other simulators fail to accurately model the very firmament within which aircraft do what they do – the atmosphere. Without that in place, it doesn't much matter what kind of flight model tech is running: if the atmosphere isn't realistic, *nothing else will be either*.

Add to that the accurate satellite coverage that MSFS has world-wide and out-of-the-box, allowing for real-life VFR flying techniques, and you have what is quite simply the most accurate rendition of planet Earth that flight simulation fans have ever seen. Sure, there are issues and bugs, but when those are placed against the vast scale of what Asobo Studios has achieved, it's pretty clear that nothing comes even remotely close to MSFS in terms of its realism.

Related to this is one of the other quotes I started this document with;

“The airplanes are not study-level! It's a game, not a simulator!!”

I build medium-level detail aircraft for the commercial, entertainment user. I resolutely *avoid* building study-level aircraft, as I know from long experience as both a user and a developer that most simmers don't actually want them. The vast majority of simmers want something in-between; detailed enough to be interesting, but easy enough to learn so they don't have to spend three months reading a manual just to start the engines. True fans of absolute study-level aircraft are in fact a minority group in flight

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

simulation, although of course sufficiently numerous to represent a large sales market for developers who build more complex aircraft.

However, regardless of the user's personal preference, modern flight simulators like MSFS are sufficiently complex, and the environment in which they operate sufficiently realistic, that most of the problems faced by real-life pilots are by definition faced by simulator pilots when it comes to actually flying and operating *any* aircraft, even those that are deemed “mid-level-complexity”, in the MSFS world.



The flight deck of the “mid-level-complexity” DC Designs Concorde in MSFS. Yes, every switch works. Even at this medium-complexity level, if you don’t know much about the airplane or aviation, you’re going to struggle to get Concorde to perform the way it’s supposed to.

I also used to say that all simulators are at heart “games” and can never replicate the real-world experience of flying. My reason for saying so was that I was unfortunate enough to face a real developing emergency during my PPL flying training, while alone as Pilot in Command of a PA-28-181 Warrior. That situation is something that only other people with real PIC experience will be able to appreciate. There is no “Pause Button” in real aviation, no “re-starting” the flight. When things go wrong, you’re on your own and if you are unable to resolve the situation, aviation can become a fatal endeavour. Alone at 3,000ft with a failing engine is the only place where you can really appreciate the difference between a flight simulator and *flying*.

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

However, despite all of this I recently saw a comment by a simmer that said: *“All simulators are what you make of them. If you want to use them as a simulator, you can. If you want to use them as a game, you can. You can fly upside-down under a bridge in simulators that are used to train real pilots, if you want to. They may not be designed for it, but who cares if that’s your personal preference? Each to their own.”*

I instantly recognised this as a fairer assessment of what flight simulation represents. It’s what *you* want from it. The snobby elitism of those who will only fly “study-level” airplanes, and seem to want to look down upon those who fly or develop anything else, belongs nowhere in this hobby. (Upon investigation, most of them also have no real flying experience either). I know many serving and former military and commercial pilots who thoroughly enjoy using MSFS. They did/do the real thing for a living, so if they’re good with it, so am I. MSFS is realistic enough to be used as a highly accurate flight simulator, in fact the most accurate desktop simulator in the world. Or you can use it to land a 747 on an aircraft carrier. It’s up to you.

However, remember that as MSFS is *capable* of being a very realistic simulator, if you want to get the best out of your flying experience within it, it’s worth learning a little about flying real airplanes. That’s the purpose of this document – to correct a few common misconceptions, explain a few seemingly minor yet highly relevant features of flying, and generally put the record straight on a few things. The next few pages will, I hope, clear up some of the most oft-asked questions about aviation in MSFS, and allow even the absolute beginner to understand why certain things are done, why certain things happen, and why you cannot buzz your house at Mach 2 in the DC Designs F-14 (hint: it’s because it can’t be done in real life either - it’s aerodynamically impossible.)

(*N.B. There are some aircraft in MSFS that are **highly unrealistic**, for reasons you are about to learn. These products may be one reason why developers have to field questions like those at the start of these pages. DC Designs don’t build high-fidelity aircraft, but our flight models, despite what you might read elsewhere, are as realistic as MSFS can produce and very close to those of the real aircraft they portray).*



The DC Designs F-14A Tomcat. Real F-14 pilots helped with advice on the flight dynamics of this product, as did real pilots of all the other airplanes I have built, except Concorde. If you have flown a real Concorde, you should know that I cheerfully offer beer in return for knowledge.

The in-sim Interactive Checklist

Use it, for all airplanes in MSFS. I get so many questions or supposed bug-reports from people who can't find such-and-such a switch in the cockpit, or can't fly the airplane properly, who have not used the Interactive Checklist. It's there to show you how to fly the airplane, and to show you where all the controls are. The checklist in Concorde will actually guide you through an entire flight. Use the checklists!



The Interactive Checklists supplied with the DC Designs Concorde, selected via the menu.



NO PRESSURE

Ambient air pressure is something that affects aircraft a great deal, although it's rarely thought about by most users. Most don't really look at an altimeter beyond making sure they're not about to collide with the ground, because an altimeter measures your height above the ground, right?

Wrong.

Earth's atmosphere is held in place by the same force that keeps your feet on the ground – gravity. Air pressure is measured in millibars (inches of mercury, Hg, in the USA). With all that atmosphere above us pressing down via gravity, the pressure is higher down here. The higher you go, the less the pressure and the thinner the atmosphere. Go too high, above around 12,000ft, and breathing becomes difficult as the air is too thin. Also, air temperature decreases by approximately one to two degrees Celsius per 1,000ft of altitude (there are several lapse rates depending on conditions). So, if it's 20 degrees Celsius down here, at 20,000ft it will be between 0 and -10 degrees.

In brief, an altimeter measures your altitude above whatever *pressure datum* you set it to. This subject can get quite mind-bending and beyond the scope of this document, but it's worth covering briefly. What this means is that there are variations in how an aircraft's altitude can be read. I'm sure you've all seen the weather forecasts, with areas

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

of low and high pressure. Change the air pressure, and the altimeter changes with it. So how do you know how ‘high’ you are?

Air pressure in aviation is most commonly measured based on what is called the International Standard Atmosphere (ISA). At ISA conditions, the air temperature at sea level is 15 degrees Celsius, and the air pressure is 29.92 Hg (1013 millibars). That little knob on your altimeter that you can turn sets the altimeter to measure your altitude above *sea level* – if ATC tell you that the setting is 29.92 Hg, then you turn the knob until the little window reads 29.92, and the resulting altitude on your altimeter is your height above *sea level*. This is referred to by Air Traffic Control as “QNH”.



A typical altimeter, here reading a pressure datum of 29.92 Hg (1013 millibars in Europe) Turning the little knob on the lower left will change the pressure datum to match the air pressure in the region you’re flying in. In this case, 920ft altitude above sea level.

But, imagine that you’re flying at an altitude of 920ft over the sea, and you reach land. Your altimeter is telling you you’re at 920ft, and you look down and sure enough, the sea is 920ft below. The land looms up, and you see cliffs that are 820ft high. The cliffs pass beneath you, and you’re suddenly skimming tree tops at 100ft – but your altimeter still reads 920ft!!

This is where ATC comes in. Air Traffic Control will, as you pass from station to station, give you the *local* air pressure “QNH”. Airfields that you fly to will have an “elevation” – their height above sea level. If you’re told to fly at 2,500ft on QNH 29.92, and your destination airfield is 300ft Above Sea Level, then as you pass overhead that airfield with the assigned QNH in the altimeter, you will know you’re actually at 2,200ft

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

altitude above the runway of that airfield (QNH pressure-altitude minus airfield-altitude).

Now you know that you can set your altimeter to local air pressure by winding off 300ft's worth of pressure, or by requesting "QFE" from Air Traffic Control – the air pressure setting at runway height. Now, when you join the circuit and land, you'll be at the correct altitude, and will touch down with an altimeter reading "0" ft as your wheels touch down on the runway.

This does sound quite complex to remember, but it is a daily requirement of real life aviation for obvious reasons (like not flying into mountains and things) and worth understanding so that you can operate and understand your instruments and how they work. Tune to a local ATIS on your radio (Air Traffic Information Service, the frequency for which is available at all airport locations in MSFS) and you will be told the local air pressure as part of a repeating meteorological report. In a pinch, hitting the "B" key on a keyboard will also set your altimeter to local QNH.

So, the bottom line is that your altimeter tells you your altitude based on the current air pressure in the region in which you're flying, and ATC will keep you informed of the correct setting so that you don't end up flying into arguments with big things like hills and mountains. Setting the altimeter to your runway height (QNH minus airfield elevation = QFE) will give you your true height above the airfield.



GETTING OFF THE GROUND

Watching some people trying to take-off in MSFS is quite painful. So many simply accelerate down the runway to “ludicrous speed” and then haul the stick back and fly the airplane off the runway and into the sky. The nose plunges up and down, their airspeed is all over the place. If they’re trying to take-off in formation, it’s a mess.

Various forums are full of people complaining that any given aircraft’s flight model is poor, ground handling is awful, terrible job by the developer etc. Most of the time, the airplane is fine and it’s really the user that is at fault. Don’t assume it’s limited to newcomers either. One excellent third-party aircraft, a WW2 piston-engine fighter, was rejected by the Microsoft Marketplace test-team as they could not get it off the ground. “The flight model is not acceptable” was their reasoning. It turned out that none of them had read the manual. The developer sent them a video of the aircraft taking off perfectly, and after trying again, the MS team cleared the aircraft for the Marketplace.

Aircraft don’t *fly* off a runway. They accelerate, then they “rotate” to a take-off angle, and then...., the pilot waits. As the speed builds, so the lift generated by the wings increases, and eventually the lift generated exceeds the mass of the airplane and it lifts off the runway. *Accelerate. Rotate. Wait.*

All airplanes have their own take-off procedures, but broadly speaking the main points are:

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

1. Aircraft flaps set to the correct angle.
2. Elevator trim to the correct take-off setting.
3. Controls full-and-free movement
4. Throttle set to take-off power
5. Accelerate down runway to rotation airspeed
6. Rotate nose to correct angle and wait
7. Lift off

Trim? Why do I need to trim? What on earth *is* trim?

Simply put, the faster an airplane goes, the more it will want to lift its nose and climb, because increasing speed equals more lift. The slower it goes, the more it will want to drop its nose and dive as speed and thus lift decreases. The trim wheel saves the pilot the effort of constantly having to hold the stick either back or forward to combat this. Trimming well makes for a “light stick” that is easy to handle. When taking off, where speed is low, you don’t want to have to haul the stick all the way back just to get the nose up. Take-off trim is set so the aircraft responds easily to small stick movements.

It’s by following this procedure that aircraft of identical types are able to take-off in close formation with such apparent ease. Both pilots have followed the same procedure and have light sticks, so they can focus on station-keeping – other than that, each aircraft will respond in almost identical ways as they lift off and climb away together.

Once airborne and accelerating, you will find you need to keep trimming the nose down. This is flying, it’s the same in real life. Get used to it, as it soon becomes second-nature. Aircraft are trimmed all the time (except some fly-by-wire types).

As a final note, another thing that few users consider is aircraft weight. The heavier an aircraft is, the faster it will need to be going before it can “unstick” itself from the runway and start flying. The procedure is the same, but the airspeeds for actual lift off will vary depending on weight.

So, to be a top-banana when flying on-line and the envy of all those who witness it, set your airplane up correctly *before* attempting to take-off. Then *accelerate*, *rotate*, *wait*. Then fly.



COMING BACK DOWN

The most common cause of stalls and loss of control in flight simulation, when in the landing configuration, is excessive weight. All aircraft have a series of weight limitations. An F-14A Tomcat has a maximum *take-off* weight of 72,000 lbs, but it cannot *land* at that weight. Max-trap in the F-14A was 58,000lbs. This is why aircraft often have to dump fuel if they find themselves suddenly required to land unexpectedly early.

Newcomers to flight simulation don't realise that aircraft have these limits, and thus attempt often to land with full fuel tanks and a full set of ordnance hanging from their wings, and wonder why the aircraft flies like a brick and drops out of the sky.

The same issues apply to maximum take-off weight, and other factors such as landing-roll, approach speeds etc. All of them are also determined by ambient environmental factors such as windspeed and direction, air temperature (and the resulting air density) and other meteorological factors that affect how an aircraft operates.

The bottom line here is that a pilot must fly "*by the numbers*" in order for their airplane to operate in the way that they are expecting it to. In the case of an aircraft like the F-15C Eagle at the maximum landing weight, its approach speed is around 150 knots, with 6-degrees angle of attack. However, the similar but heavier F-15E Strike

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

Eagle might approach at up to 190 knots if it's heavily laden (but must still be within landing weight limits).

The way around this for many aircraft is to “fly” the Angle of Attack indicator. The angle-of-attack is the angle of the aircraft's pitch relative to the direction of flight. At landing this does not change no matter what the aircraft weighs (within limits). An F-15C can approach at 150 knots when light, or 170 knots when heavy, but the AoA remains the same at 6 degrees. Therefore, the pilot refers only to AoA upon approach – get a green light in the AoA indicator, and your approach glideslope will be correct for the weight of the airplane.



DC Designs F-14A Tomcat demonstrates the ideal landing configuration. The bright circle to the left of the HUD shows that the airplane is at the correct AoA. Airspeed is 137 knots, AoA is 7.6 degrees. DLC is engaged, full flaps deployed.

Many users don't really know how to configure an airplane to land correctly, and so they end up bobbing up and down, coming in too steeply, too shallow, too fast or too slow, and everything quickly goes to hell in a handbasket.

Landing is the most vulnerable phase of aviation. The aircraft is close to its stall airspeed, and therefore always in some danger, yet if flown correctly landings are not only easy (under normal meteorological conditions) but even fun.

The best way to learn to land (and to take off) is to do circuits. Circuit-bashing is the first part of any real-life flying training, allowing the student to learn the

peculiarities of the aircraft they're flying while staying close to their home airfield. In the case of landing, the process is in many ways as simple as that of taking off.

1. Altimeter set to runway height (or local QNH)
2. Airspeed reduction
3. Deployment of flaps and undercarriage / trim
4. Aligned with runway
5. Descend until threshold
6. Power to idle, flare for touchdown

Simple, no? Of course not. One of the biggest misunderstandings about aviation is how an airplane flies in the landing configuration. The easiest way to explain it is that at low landing airspeeds, the stick controls airspeed and the throttle controls descent rate.

What?!

Yes, it's true. Ever watched a fighter jet coming in to land, and seen little puffs of smoke from the engines as the power comes in and out? That's the pilot controlling the descent with power. The aircraft is settled at the correct *attitude*, and the pilot is using *power* to keep the airplane pointed at the start of the runway, and *stick* to maintain the correct airspeed to avoid a stall or overshoot.

When the airplane crosses the runway threshold, the pilot pulls the power to idle. The airplane sinks as airspeed decays, and then the pilot raises (flares) the nose a little to slow both the descent and airspeed. The wheels touch down, and the landing roll commences.

Just like take-off, there is a set procedure, and when followed correctly it results in predictable behaviour from the airplane, each and every time. All that the pilot needs to do is correct for crosswinds and maintain their approach. But, what about the correct glideslope? How can a newcomer know how to fly that correct approach if there is no Angle of Attack indicator?



Airfield PAPI lights to the left of the runway, showing two green and two red lights – our hero is on the glideslope, right where they should be

Most airfields will have PAPI lights, a row of four high-intensity lights to the left of the runway threshold. If you're on the correct glideslope, you'll see two reds and two greens (sometimes two reds and two whites). Too high, you'll see all greens. Too low, all reds. Use your throttle in the approach to keep those two reds and two greens, and be the envy of all simmers wherever you fly. Power up to reduce your descent rate, power down to increase it.

In summary, make sure your aircraft is within landing weight parameters, make sure your altimeter is set correctly for the runway in question (check the required pressure setting with ATIS on your radio), get the airplane set up for landing *before* you try to land (gear down, flaps and trim set, airspeed correct) and then line up while using your throttle to control the descent rate and your stick to control your airspeed.

It will take time and practice, but you will soon be able to land your chosen airplane perfectly wherever you take it. To help real pilots in training, we create little mnemonics to help check that everything is ready. For the downwind phase of flight, the mnemonic I used in real life was:

BUMFICHL

This slightly amusing little mnemonic stands for:

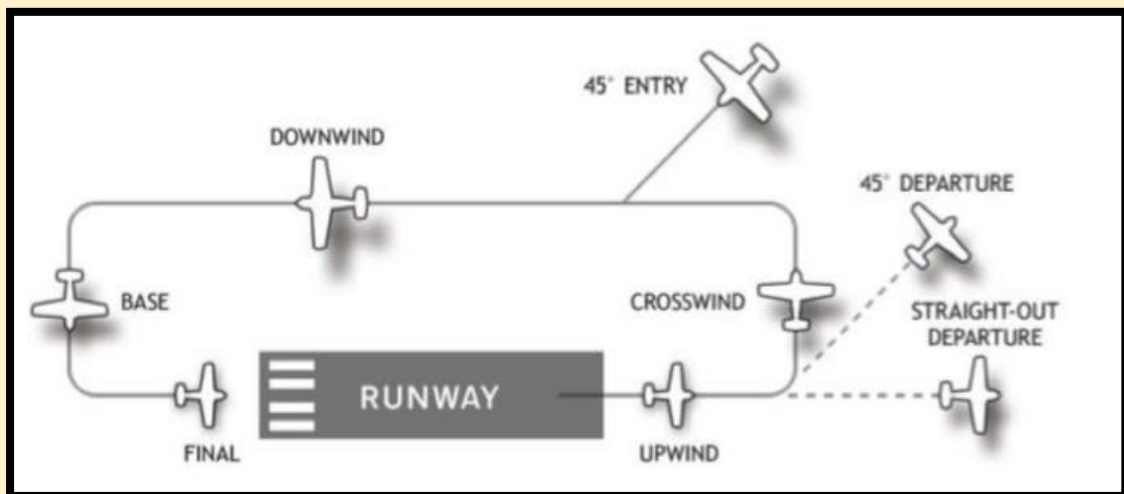
Brakes, Undercarriage, Magnetos, Fuel, Instruments, Carb heat, Harnesses, Landing light.

This is a stock safety checklist conducted by pilots all around the world every day, with slight variations depending on aircraft type and pilot preference. Real aviation is filled with these mnemonics that help ensure the safe operation of aircraft. There's a reason that air travel is the safest form of transportation on earth – pilots are well trained to reduce the chances of problems arising and, if they do, getting out of control.

Another well-known mnemonic, used when cruising, is **FREDA**:

Fuel, Radio, Engine, Direction, Altitude

Each word reminds the pilot to check fuel contents, radio frequencies correct, engine instruments showing normal operation, compasses showing correct heading and aligned, and altitude setting and reading both correct. Pilots will do this check often during a flight, to reduce the chances of any one value slipping too far out of acceptable parameters and causing a mishap.



Simple aircraft circuit plan. The BUMFINCHL check is done while downwind.

CRUISING TO VICTORY



So, you can take off and you can land. Victory is in the bag, right?

Well, no.

Most people in MSFS can boom and zoom in fighters, or cruise in airliners using autopilot, but many can't *fly* all that well. It's easy to just buzz around in MSFS and look at the scenery, but how do you know where you are or where you're going? How do you know how much fuel you have left, and how far it will get you? Sure, you can look at the VFR map, and you might have half a tank of fuel remaining, but what does that actually mean for endurance? And if you're lost in cloud, how can you find your way home to your airfield without recourse to the VFR map?

The arts of airmanship and navigation are themselves vast and too much to bore you with in such a short document, but in brief, this is how it all breaks down.

Firstly, the *flying*. Airspeed. Heading. Altitude. Maintaining these three correctly, as it turns out, requires considerable practice, and it's the same in real life. Flying straight and level isn't easy until you've built some experience at it. Making sure the airplane is trimmed, setting correct engine RPM, watching the heading and altitude all require attention, and even a light aircraft like a Cessna 152 cruises at 90 knots or so (100 miles per hour). On top of doing all that that, a pilot must monitor ATC chatter in case they're called upon by their controller. All of this requires considerably greater aptitude than

many initially expect. Student pilots find themselves “behind the airplane” quite often in the early days of training. In order to “get ahead of the airplane” and keep control of things, you need to know where you are, where you’re going and how fast.

There are two main types of navigation in the real world, and in MSFS.

VFR NAVIGATION

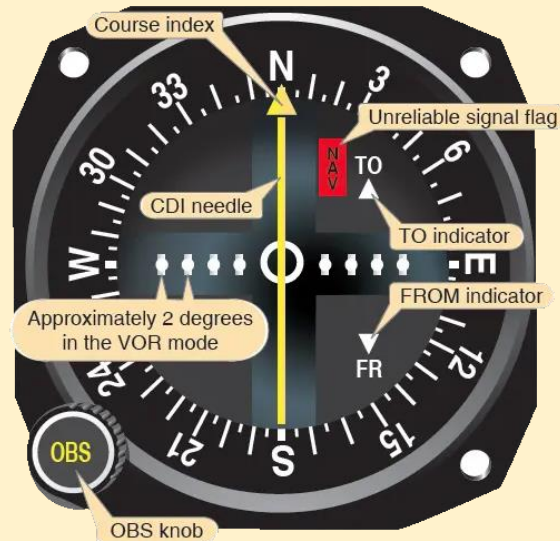
This stands for Visual Flight Rules navigation, and is the standard form of flight for most PPL aircraft. Aircraft must stay within sight of a horizon and in daylight, and use a mixture of visual references (roads, towns, villages etc), radio-navigation and Air Traffic Control to find their way around. It’s not unknown for VFR pilots to carry binoculars with them, to look at road signs below for verification of position.

IFR NAVIGATION

Instrument Flight Rules navigation is used by commercial and military aircraft, and by private pilots with sufficient extra training, and allows an aircraft to fly at night, in poor visibility and above overcast cloud layers.

In MSFS, the instruments used work in much the same way as real life, but of course without the safety and training requirements attached to the more advanced methods of flying. In real life, flying at night or in zero visibility (especially both) is far more demanding of a pilot than ordinary VFR navigation.

Flight planning is essential to assist the pilot in knowing where they’re going. MSFS is accurate enough that for VFR flight, it is possible to use a real aviation map or any other kind of map to find your way around. For IFR flight, the need to operate navigation instruments is essential, as you may often not be able to see where you’re going, and even the in-sim VFR map will not be accurate enough to guide you as it only shows basic position and heading information.



The VOR indicator in a typical aircraft. The yellow line rotates via the OBS knob to point at the radio station, and the centre of it then moves left or right to show how far “off” the correct course the pilot is. To get onto the desired course, the pilot flies toward the detached centre line, which eventually lines up with the yellow arrow to show the aircraft is on the correct, selected course to the VOR station.

VOR INDICATOR

This mysterious device simply shows your airplane in the centre as viewed from above. The pilot tunes the frequency of the desired destination, and turns to OBS knob to the heading they want to arrive on when they reach the VOR station. The yellow arrow turns to the selected heading, while the centre section of the yellow line detaches to the left or right, showing the pilot which direction to fly to intercept the chosen heading to the station. As the aircraft reaches the correct position, the line will gradually move back in and attach to the yellow arrow.

The white TO and FROM arrows tell the pilot if they’re flying toward, or away from, the station. Most times, you will want to be flying with the TO arrow showing.

Depending on altitude, a VOR indicator can have a range of up to 150 nautical miles.

The VOR station itself is a radio-transmitter that can be thought of as a spoked bicycle wheel viewed from above, with the station in the middle and each spoke representing one of 360 degrees. These spokes are called “radials”.

Very basic example: You’re flying to Biggin Hill (UK) VOR, which is on frequency 115.10. The active runway is 21. So, you’d select the VOR frequency, then rotate the

dial to a heading of 210. You'd then point the airplane toward wherever the yellow line has detached to, and fly toward it. When it lines up with the yellow arrow again, turn onto heading 210, ensuring that the white TO arrow is also showing. You're now flying direct toward Biggin Hill and will arrive already lined-up to land on runway 21. The line you have intercepted and then flown along is one of the "radials".

By selecting a flight plan in MSFS, using IFR (airways) and then noting down the required frequencies of various VOR stations along the route, you can now plan an entire flight and could, with practice, fly the entire route at night and above cloud, without ever seeing the ground other than when taking-off and landing.

There are some other indicators that also allow you further references to improve navigation and flight planning.

VOR/DME

A VOR/DME station allows you to also see a Distance Measurement Estimator. When the aircraft radio is tuned to a VOR/DME, the VOR indicator works in the same way, but the radio will also show the distance in nautical miles to the station. This allows the pilot a further position fix and the ability to plan time of arrival as well as monitor fuel to ensure sufficient for the full journey.



A typical aircraft radio displaying DME (63.8 nautical miles), airspeed (168 knots), ETA (23 mins) and frequency. Very useful for planning your flights in MSFS just as they are planned in real life. The sharp aviator will work out how to calculate ETA on their own using maths... 😊

There are other indicators such as ADF (Automated Direction Finder) that can be used, but I suggest further research into these if you're interested. There are many

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

tutorials on-line, and of course there is training available in MSFS to learn the use of these instruments. I highly recommend doing so as, once mastered, it makes flying in MSFS immensely more satisfying and enjoyable.



DC Designs Concorde in IFR flight conditions. You can see the Horizontal Situation Indicator in the centre of the Captain's panel, below the big artificial horizon, which contains the VOR display. Concorde's selected radial (yellow separation line) is out to the right by about three degrees, with the aircraft tracking gently toward it to intercept. The white "TO" triangle confirms the pilot is flying toward the VOR, in this case an airport. The DME display further to the left is showing 7 nautical miles to the VOR. (Concorde's low airspeed, altitude and lowered nose screen reveal that this image was taking while lining up to land in bad weather, during flight testing).

Some further simple navigation techniques

Time, speed and distance

If you're cruising at 100 knots indicated, then you're covering 100 nautical miles per hour. In 30 minutes, you'll cover 50 nautical miles. In fifteen minutes, 25 nautical miles, and so on. (Ground speed will become the more accurate reference if you're cruising at higher altitudes). Use this simple arithmetic to calculate time of arrival.

The one-in-sixty rule

This is a “*rule of thumb*” which states that if an aircraft has travelled sixty miles, then an error of track of one mile is approximately a one-degree error in heading, and proportionately more for larger errors.

Flying gusty approaches

If you’re coming in to land in rough weather, and want to know how to ensure your aircraft maintains minimum flying speed, add half the gust factor to your airspeed. If you’re landing at 70 knots, and gusts are at 20 knots, fly your approach at 80 knots.

Descent rate calculations

If you descend at one degree nose-down, for every nautical mile you fly, you will descend 100 feet. If you have, for instance, one mile remaining to your destination and need to descend 600 feet, you will need a six-degree angle of descent.

Take-off weight estimations

If you’re aircraft is 10% heavier than normal, the take-off and landing distance will increase by approximately 20%

When to start your descent into an airfield?

Divide the altitude you need to lose by 300.

If you’re at 12,000ft, and the airport has a circuit height of 1,000ft, then you need to descend 11,000ft. $11,000 / 300 = 36.6$ nautical miles from the airport.

Descending at a three-degree angle will mean you’ll arrive at the airport at circuit height.

MYTH BUSTING

So, having covered a few of the basics for you about how airplanes operate and the environment within which they fly, I'd now like to dispel a few common myths that are often perpetuated across the Internet by the kind of people who won't bother reading documents like this one. As you now understand, I hope, a bit more about the basics of aviation and airmanship, these examples and my explanations will make more sense.

These are all actual comments (often coming from many different users) that have been sent to me over the past three years of being a full-time developer for flight simulation. Each has been selected due to so many users being under illusions about what aircraft can do in real life as well as in MSFS.

“The F-15 Eagle should go 1,400 knots! I can't get more than 1,000 knots even in a steep dive!”

I've lost count of the number of times I've read this one. Mostly, I think the misunderstanding comes from Internet descriptions of aircraft that list their maximum airspeed, such as those on Wikipedia. For the F-15 Eagle, this is indeed 1,400 knots or thereabouts. That airspeed is equivalent to Mach 2.5. The problem comes when folks don't understand the difference between the various available measurements of *velocity*.

Velocity can be measured in Knots Indicated Airspeed, True Airspeed, Calibrated Airspeed, Ground Speed or Mach. What's the difference? Well, the *air itself* is the difference. Airspeed is measured through something called a Pitot Tube, which is often found poking out of the nose of an aircraft. As the airplane flies through the air, the air passing into the tube is measured, resulting in the aircraft's Knots Indicated Airspeed. One knot is one nautical mile per hour. So far, so easy.

The problem is that the higher you go, the *thinner the air gets*, remember? The speed of sound (Mach 1) at sea level is **660 knots** under normal ISA conditions. At 40,000ft, the speed of sound is just **573 knots**, because the air moving into the pitot tube is far thinner up there and thus records a lower figure. For this reason, above a certain altitude, pilots no longer refer to knots indicated, and instead refer to Mach. (They can, and do, still reference knots indicated if required, but for most purposes Mach is used).

So why do reference materials report that the F-15 Eagle can reach 1,400 knots?

The reason is that the quoted figure is usually the aircraft's *Ground Speed*. Ground Speed can be thought of as a laser-beam fired from the bottom of the aircraft to the ground below, tracking along as the aircraft moves. For our F-15 Eagle flying at **Mach 2.5 at 50,000ft**, although the aircraft instruments say that it's apparently only moving at 660 knots indicated, its Ground Speed – the laser spot tracking along the ground below - is moving at somewhere above 1,400 knots, and this figure is what you see quoted so often. When judging an aircraft's maximum velocity at altitude, look for **Mach**, not Indicated Air Speed. This also covers another common misconception;

“The wings on the F-14 Tomcat should sweep by 300 knots indicated. They don't move until 500 knots. This is inaccurate!”

This difference in air pressure at altitude neatly explains why the F-14 Tomcat's wings take longer to sweep back in auto-mode than people think that they should. The F-14's wings sweep based on *Mach*, not Indicated Airspeed. They start their sweep at Mach 0.7, and only reach their maximum angle of sixty-eight degrees at Mach 0.96. Mach number in the denser air nearer the ground has a higher equivalent Indicated Airspeed (660 knots). At sea level, the point where those wings start sweeping, Mach 0.7, equates to 460 knots indicated. So, it takes longer for the wings to start sweeping when down low, than if the F-14 were at 20,000ft, when Mach 0.7 will be reached at a lower indicated airspeed. Simple.

Finally, this air pressure that is a feature of our entire planet and is the reason why you can't do a Mach 2 fly-by of your own home at tree-top height. No aircraft in the world can achieve Mach 2 at sea level. The denser air building up in front of the aircraft produces a wall of pressure (shock-wave) that exceeds the thrust of the engines. The thrust and drag curves of any airplane at sea level meet long before Mach 2 can be reached. The fastest aircraft in the NATO inventory at sea level was the Panavia Tornado F3, which could reach Mach 1.3. The F-14 and F-15's thrust and drag curves at sea level meet at around Mach 1.2, which is around 800 knots indicated – precisely what folks see in our products in MSFS. If you know of an aircraft in MSFS that can fly at faster than Mach 1.3 at sea level, it's inaccurate, simple as that.

“The real F-15 Eagle can pull 9G and -3G, but I can’t get it beyond 6G!”

This again is a common complaint seen on various forums. The F-15 Eagle can indeed perform turns with such accelerations as 9G, but only *in certain configurations*, mainly based on aircraft weight. The stated G-loadings are also operation airframe-*maximum* loadings. In addition, there is a difference between maximum-rate turns and sustained-rate turns.

An F-14A Tomcat at maximum take-off weight is limited to 6.5G. An F-15C Eagle in the same configuration is limited to around 7G. If they’re carrying external fuel tanks on their wings, the restriction is even greater, as the forces upon those wings in combat would have the potential to rip the wings off if they were sufficiently over-stressed. It’s for this reason that combat pilots jettison their external fuel tanks before heading into a dogfight, and fighter pilots always like to get rid of heavier air-to-air missiles first; *less weight means more manoeuvrability*.

There are instances when such limits are exceeded. In the *Gulf of Sidra* incident in 1981, when a pair of F-14A Tomcats of VF-41 *Black Aces* iced two Libyan SU-22 Fitters, one of the Tomcats was forced to make a 10G pull-up to avoid debris from the Sukhoi it had just destroyed. The Tomcat emerged unscathed, but required an inspection after landing to ensure there had been no damage to the airframe caused by the aggressive manoeuvre.

Sustained 9G turns are possible in some aircraft, in some configurations, the F-16 Fighting Falcon being a notable example, but in many cases it’s the pilot that is the limiting factor, not the airframe. There is also the potential for loss of airspeed due to the high angle-of-attack of such aggressive turns, which limits just how long an aircraft can sustain such manoeuvres. If you’re flying at 150 knots, there is no way you can pull 9G in an F-15 Eagle – it’s just not going fast enough to attain that loading.

In short; yes, an F-15C can sustain 9Gs, but only when at a lighter weights and only for short periods, just like the real airplane.



The DC Designs F-15C turns and burns with a single centre line fuel tank. With this configuration, a sustained 9G turn could be achieved, at least until airspeed bleeds off, at which point the maximum G achievable will also decrease.

There is also the difference in turn performance as desired by a pilot to consider. At 9Gs an aircraft will eventually either lose airspeed, altitude, run out of fuel due to afterburner use or the pilot will fatigue. Instantaneous turns are often made at these high-G loadings, but the sustained turn is more useful to a pilot in a dogfight. Sometimes referred to as “corner velocity”, this is the best ratio of turn rate against turn radius – the quickest turn without losing too much energy or overshooting your opponent’s turn and presenting a target to them.

What matters most to me as a developer is that the aircraft in question matches the graphs made by the engineers who built the real aircraft, and the experiences of the pilots who actually flew it. Most reputable developers work hard to make that happen.



The DC Designs Concorde, super-cruising at Mach 2.01 at 58,000ft

“Concorde won’t reach Mach 2! It climbs for a while, then stalls and crashes!”

They say a picture paints a thousand words. Looking at the one above should do the same for the associated quote. Concorde is not an airliner. It does not fly like an airliner. It was an incredibly unique airplane that, due to its capabilities, had to be flown “by the numbers” in order to achieve those remarkable feats of super-cruise at twice the speed of sound.

The DC Designs Concorde will do everything that the real Concorde did, in much the same way. Its flight model is within a whisker of the real airplane throughout the flight envelope (which took some real work as the MSFS flight model is quirky, to say the least). Using the Interactive Checklist will give the user the greatest opportunity to see Mach 2 super-cruise (although Concorde rarely actually reached Mach 2 on her most famous Heathrow-JFK runs, as the atmosphere even up that high was too warm). The explanation for that is beyond the scope of this document, but it’s a thing – the Concorde crew would “tweak” the displays in the passenger cabin to show Mach 2, even though they were mostly cruising at a lower Mach number.



“My F-15 Eagle weighed 60,000lbs, and the engines produce only 40,000lbs of thrust in full afterburner, yet I went into a level max-G turn and the Eagle accelerated! It obviously should have slowed down due to drag!”

It seems like common sense, right? The engines are producing less thrust than the mass of the aircraft, so it surely cannot accelerate when it's in such a high-G turn, with all that extra drag from the high angle-of-attack?

Well, actually yes it can.

For a start, the inertia of twenty tons of fighter jet does count for something, although it is largely offset by the aforementioned drag. However, the real factor here is the engines. As we have already seen, when people get their information from Wikipedia they don't get the full story. There, and elsewhere, the engines on the F-15C Eagle, for instance, are reported as having a maximum thrust with afterburner of 23,770 lbs. Therefore, a total of 47,540 lbs of thrust available. If the Eagle is at 60,000lbs and loads up into a level max-rate turn, it should by all the known laws of physics slow down, right?

The reality is that the stated thrust on most of these kinds of pages is the maximum *static* thrust – that is, the thrust delivered by the engine on a rig on the ground. When the aircraft is flying through the air, things are very different. The air flowing into the engine, and also flowing around the fuselage into the exhaust plume, can increase the

DC DESIGNS MINI GUIDE TO AVIATION IN MSFS

engine thrust by up to 40%. That's a maximum thrust in afterburner for the F-15C Eagle of over 66,000lbs at Mach 0.9. Still think it should be slowing down in a max-rate turn?

Put simply, engine thrust is dependent upon Mach.

At slower airspeeds, below Mach 0.6, the F-15 and most other fighter jets will indeed bleed airspeed in a max-rate turn, in both real-life and in MSFS, as users expect them to. In combat, although it may seem that pilots would want all that extra thrust, it isn't always a good idea: greater airspeed increases turn radius, meaning an enemy could turn at a slower airspeed and get in behind them. Hence, "corner velocity" is used.

This airflow phenomena was most famously used by Concorde, which was able to super-cruise (supersonic without afterburner) due to the engine reverser buckets being positioned slightly closed when supersonic. This action deliberately diverted the supersonic airflow moving over the wings directly into the engine exhaust, almost doubling thrust without having to light the afterburners. Clever stuff, to say the least.



"The flight model feels 'off' after the latest update, it was fine before."

This one comes up from time to time on all developer's airplanes, even when they have not changed the flight model at all and when MSFS itself has not been updated. It's in fact one of the most common phrases on forums around the Internet. When users say the same thing to me, the first thing I ask them is;

“What time of year was it?”

This response is usually met with a blank stare. *What on earth does that have to do with anything?* Well, everything, actually.

During my flying training, my trusty PA-28 would usually climb at a rate of about 1,000 ft per minute after take-off. However, one chilly December morning, I saw a climb rate of almost 2,000ft per minute in the very same airplane, at the same weight. How? The answer surprises most people:

The air was colder.

Cold air is more dense than warm air. This affects all aircraft, and basically means that in the warm air of summer, performance is degraded. In winter, it is enhanced. Climb rates, available power, even overall lift is significantly improved in cold air temperatures. Now, simmers often buy an airplane and fly it for a while, then leave it aside as a new one takes their fancy. Then, months later, the hard-working developer releases an update to their airplane, and our simmer flies it again to see what’s changed. The difference is that it’s now a different *season*.

“The flight model feels ‘off’ after the latest update, it was fine before,” they conclude.

The reality is that MSFS is realistic enough to model the differences experienced by real airplanes in different seasons and temperatures, and that’s often what these confused simmers are noticing.

The difference in air temperature, even throughout a single day, has been sufficient to cost lives in real aviation, with pilots forgetting to consider it when trying to take-off on a hot summer’s afternoon. The plane flew fine that morning (it was cooler then), but now it won’t climb after take-off, no matter how much power they apply, and suddenly they realise they can’t stay in the air and that the wings are stalling. The results are always unpleasant, and sometimes tragic. If the flight model in your favourite aircraft feels “off”, consider the time of year and the ambient temperatures and densities, not to mention the aircraft load-out.

(N.B. Winter, of course, brings its own hazards to aviation, not just in terms of the weather but insidious phenomena like rhyne ice that can and has killed the unwary in the past.)



“Military aircraft should not be allowed in Microsoft Flight Simulator. It’s for civilian aircraft only.”

I have saved this precious little gem until last, as it is something that has been written so much on the Internet. As a developer who mostly focuses on military aircraft, I find this comment is made by those most ignorant of what *flight* simulation means. Here is the explanation;

Microsoft *Flight* Simulator.

The clue is in the name.

If it flies, it’s fair game in MSFS. There are *absolutely no other requirements*.

As far as military systems and weapons go, the Flight Simulator legacy series have produced third-party add-ons with weapons systems every bit as complex and diverse as any other simulator platform. MSFS, which uses the same under-lying architecture, can also support those same add-ons. At the time of writing this has not yet been performed, but with radar available in MSFS, the only thing stopping weapons and their associated systems and effects for non-Marketplace aircraft is the will of a developer to do the work.

It will happen.

CRAZY TALES!

Years ago, an aviation fan related a story about a P-51D Mustang fighter that was engaged with a Focke-Wulf 190 during World War Two. The Luftwaffe aircraft had gotten the better of the American aircraft, and was getting his nose on to the Mustang, which was in a descending spiral dive to the right and fast running out of altitude and ideas, while his airspeed was rising rapidly through 380 MPH. But there was no way he could out-run the FW-190.

The American pilot looked over his shoulder and saw the German pilot slide into his seven o'clock and take aim at him, pulling lead to spray the Mustang with bullets.

Desperate, the P-51 pilot hauled the stick into the pit of his stomach and slammed in a boot of rudder. The P-51's nose snapped up and the fighter literally flipped in mid-air as its airspeed dropped almost to zero. The American pilot kept the stick back as the Mustang completed a near-stationary backflip, and then he fired on where he thought the enemy airplane would show up as it overshot below him.

The FW-190 flew straight through his gunfire and exploded spectacularly, and the American pilot flew home in time for tea and medals.

If I had been told this tale, I would have written it off as fantasy. The airspeed and G-force would surely have ripped the Mustang's wings off? The chances of maintaining accurate gunfire under those accelerations would be almost impossible? There's no way they would teach a pilot to do that!

But, in fact, it's all true, and the aviation fan who recounted the story was the same Mustang pilot who flew the remarkable manoeuvre, that the Mustang could indeed perform, although it was no doubt considered a last resort by those who flew the P-51. You can watch it for yourself, as it was featured on a documentary called "*Dogfights*" including an interview with the pilot himself, who survived the war.

The morale of the story? Sometimes, in real life aircraft can do things that you'd barely believe were possible. If you'd seen that done in MSFS, would you have believed it, or written it off as a result of MSFS's flight-model 'inaccuracies'?

SUMMARY

Remember that line I asked you to keep in mind at the start of the document?

AVIATION IS A VAST AND COMPLEX SUBJECT

There is far too much for anybody to know everything, even highly experienced pilots. MSFS is not without its issues, there are bugs and inaccuracies. At the time of writing the lift-force value is too high, which means that aircraft are generating too little drag and can accelerate to crazy airspeeds, especially at high-angle-of-attack or high-G. Asobo know about this and are bringing out a fix in SU11. But these bugs in such a vast and complex simulator are to be expected, and will over time be ironed out.

The many folks hiding behind pseudonyms while duking it out in forums and chat rooms across the Internet rarely have the foundational experience or knowledge to pass judgement on any developer's aircraft when it comes to realism or accuracy. While not all reputable developers have a qualification either, they do spend many long months studying real aircraft manuals in order to replicate the characteristics of those aircraft as realistically as they can in MSFS. That hard-earned knowledge gives them the edge over the average simmer.

Be yourself. If you're a newcomer to flight simulation, do what you want to do with it as a hobby. Don't be swayed by those who deceive only themselves when they say that only study level airplanes are worth it. Don't listen to folks who claim that "*their sim is the only one that should be used for <insert function here>*". MSFS is a great simulator with a tremendous future. The other simulator platforms are all also good at what they do. But across the board, MSFS is leagues ahead of the others in replicating the *experience of flight over our planet*, and if you're lucky enough to have a good set-up and a virtual reality headset, you really are as close as it's currently possible to be to sitting in a real aircraft flying above our planet. Above all other things...

...enjoy it. 😊

AUTHOR'S NOTE

A bit of information about the “developing emergency” situation I was involved in while training for my PPL. I was cruising at 3,000ft on the second leg of a Qualifying Cross Country (QXC) exercise from Gloucester Airport to Nottingham (Sywell Aerodrome) in a PA-28-181 Piper Warrior. It was the middle of summer, with warm conditions on the ground of about 25 degrees Celsius. I had about 30 hours on my log by that time, and was flying solo. A few miles ahead of me was my QXC buddy, Rachel, in another Piper Warrior. (Rachel is now an airline pilot).

Half-way through the flight, my engine began to lose RPM. I added more throttle, but the engine continued to gradually fade. For a few moments I was at a loss, and then a heavy apprehension hit me as the engine began to fade faster. I became swamped by the sudden realisation that I had a real problem and relatively little time to solve it before an unavoidable date with a forced landing.

I panicked for a few moments, and then my brain got itself into gear and I stopped everything. *Aviate. Navigate. Communicate.* I sat for a moment with my mind entirely empty of thoughts, and then my training kicked in. I looked at the fuel gauges – plenty of fuel, evenly spaced on both wing tanks. I looked at the fuel tap – set to right wing, where it should be (PA-28 pilots have to swap fuel draw from one tank to the other to balance the usage). My eyes swept the instruments – all green except the dropping RPM.

The engine started to cough and splutter, the airspeed falling, but I remained strangely calm. I let the nose drop to maintain airspeed, and kept looking for the fault. My hands gently touched each of the controls and switches, moving from left to right, checking everything, and touched on the Carburettor Heat lever. In a moment of revelation, I engaged the carb heaters. Ten seconds later, the engine surged as the power came back and conditions returned to normal.

I throttled back and took a few moments to learn to breathe again, while deciding whether I should change my pants after I reached Sywell. I never contacted ATC and Rachel never knew what had happened. The rest of the flight was fine and I landed back in Hampshire that afternoon, passing my QXC.

The cause of the engine problem was a build-up of ice in the Carburettor. The fact that it was summer delayed my solving of the problem, as it wasn't something I'd anticipated. But the literature is clear - carb ice can build up at *any* time of the year, as

it's the moisture content of the air itself that is paramount, not the temperature. The ice blocks the fuel flow through the carbs, gradually starving the engine and eventually shutting it down, if the pilot does not engage the carb heaters.

To an experienced pilot, this event would be something that they would have solved far sooner than I did, and it probably would not have even registered as a big deal. But accidents in aviation are rarely the result of just one factor, and more often the result of an unfortunate series of coincidental events. My inexperience at the time could have cost me my life, not because the solution to the problem was complex, but because in aviation the *psychological effect* of facing a potentially life-threatening situation is in many ways more dangerous than the problem itself. What was in reality a fairly basic issue could easily have become something far worse.

It is that *psychological difference*, between knowing that you're in a simulator and knowing that you're really *flying*, that for me will always separate the two.

My experience was a valuable lesson that I never forgot.



Sierra-Alpha, the PA-28 I flew during my QXC and which suffered the carb-icing problem. The airplane is pictured here some weeks afterward at Thruxton, where I'd landed for lunch on a solo flight to build hours, having finished my PPL training after around 38 hours of flight (45 log-book hours are required in the UK before a student can take their final skills test).

Picture credit: author, 2015.