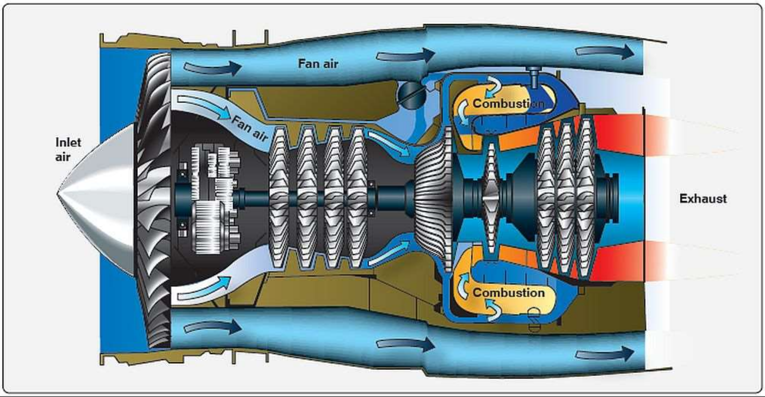

Figure 1-A: Jet engine (US FAA)

The **inside fan** is called "N2" and "high pressure." It uses the force of expelling air to spin the shaft that rotates the forward fan and other fans.

Engine-bleed systems divert clean hot air from engines for cabin pressurization and heating and for engine and wing anti-icing.

Jet pilots use several gauges to manage engine performance:

- The **N1** gauge guides primary power settings and is used during take-off, cruise, approach, and landing.
- The **N2** gauge is the primary indicators of engine power for systems such as generators, pumps, and bleed systems. Pilots pay more attention to N2 than N1 during engine start because N2 starts first.

- The **EGT** gauge (exhaust gas temperature) measures temperature of gases exiting the engine at its tail. This gauge is used in the Airbus A320, the Boeing 747-8 and the Boeing 787 Dreamliner.
- The **ITT** (interstage turbine temperature) measures temperature of gases between the low and high pressure wheels deep inside the engine. It is used in the Cessna Citation and Longitude business jets.
- The **fuel-flow** gauge provides a secondary power indication. Absent fuel leaks, higher fuel-flow rates generally reflect higher power and vice versa.

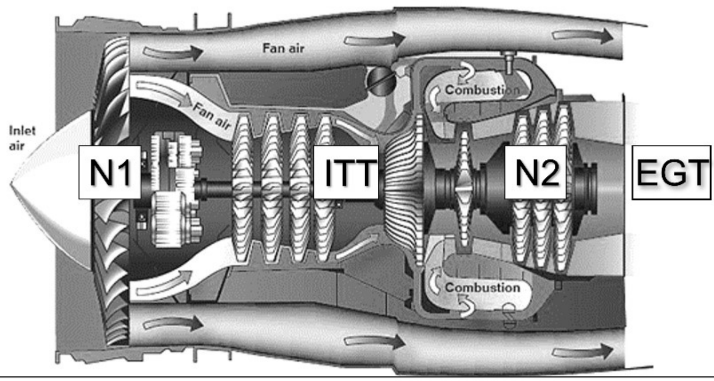

Figure 1-B: Engine gauge positions

Engine Spooling

Unlike piston engines, jet engines require several seconds to accelerate, called "spooling." It is most noticeable when taxiing from a stop, starting the take-off run from a stop, increasing speed to maintain climb rates and glide slopes, and preventing or recovering from stalls. The term derives from "spool," which is the shaft the fans are attached to, generally speaking. Engines are “spooled” when spinning at the proper RPM. Jet pilots are accustomed to spooling delays, and you will be soon enough.

Altitudes

Jet pilots use several types of altitudes such as the following:

- MSL (above mean sea level) is the standard datum for measuring elevation and altitude. It is based on the mean height of sea surfaces for all tide stages over several years.
- AGL (above ground level) is the actual height above the ground beneath an aircraft.
- FL (flight level) is an area of constant atmosphere pressure related to the specific pressure datum of 29.92 inches of mercury or 1013.2 millibars/hectopascals. The standard worldwide transition altitude is 18,000 feet MSL, and there are variations in some countries.
- MEA (minimum enroute altitude) is the lowest published altitude for a charted airway.
- MDA (minimum descent altitudes) are specified on charts for instrument approach procedures.

Universal Basic Tasks

Every commercial and private-jet pilot has similar requirements and performs similar tasks at certain points in their flights.

- Commercial flights and aircraft flying above 18,000 feet (5,490 meters) are required to follow instrument flight rules (IFR) and communicate with Air Traffic Control (ATC). Exceptions are too few to matter to us flight simmers.
- All IFR flights require IFR flight plans filed with ATC.
- All IFR pilots must comply with fuel regulations.
- All IFR pilots are required to communicate with ATC throughout their flights. Exceptions are allowed only for equipment failure.
- Pilots may engage their autopilots any time after passing through 500 feet (153 meters) above ground level (AGL). This does not mean they must do so, only that they may. Use of autopilot is pilot discretion except for the 500-foot AGL minimum.
- At 2,500 feet (763 meters) AGL, airspeed is increased from maximum of 200 knots indicated airspeed (KIAS) to maximum of 250 KIAS.
- At 10,000 feet (3,050 meters) above mean sea level (MSL), airspeed is increased to the aircraft’s recommended maximum, which is usually around 320 KIAS. Landing lights and seat-belt signs are usually turned off; they can remain on at pilot discretion.
- At 18,000 feet (5,490 meters), altimeters are changed from sea level (QNH) to standard (QNE) 29.92 inches (1,013 millibars).
- Generally between FL250 and FL300, pilots follow true airspeed instead of indicated airspeed.
- Somewhere around FL300, pilots begin using Mach and true airspeed as guides.
- The reverse applies on the descent.

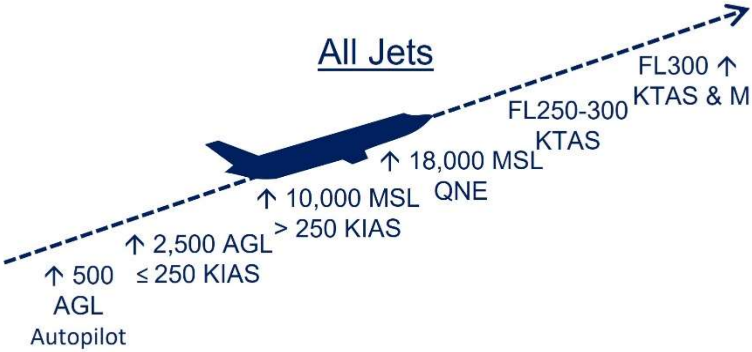

Figure 1-C: Climbing Tasks

V-speeds

V-speeds are significant velocities for operating aircraft safely. All are abbreviated with a V followed by letters or numbers such as V1, VR and V2. *Federal Aviation Regulations and Aeronautical Information Manual* (FAR/AIM) lists 34 of them. The more common regard taking off, climbing, cruising, approaching, and landing.

Manufacturers specify V-speeds for their aircraft. They differ for various aircraft and under various conditions for the same aircraft. Specific V-speeds are generally higher than specified for higher elevation airports, lower atmospheric pressure, and high atmospheric temperature.

Flight management computers in modern jet aircraft calculate V-speeds based on those and other factors, but this important feature is not reflected in Microsoft Flight Simulator™ 2020 (MSFS). Flight simmers consequently use generalized V-speeds or none at all. I have provided the best V-speeds for each jet aircraft based on the most reliable sources available. In your simulations, you are most likely to use the V-speeds shown in Table 1-A.

I use FAR/AIM's hyphenated spelling but not its subscript capital letters because they are too difficult to read.

V1 is important when an aborted/rejected take-off might be necessary. Reasons are usually another aircraft or vehicle on the runway; a runway contaminated with water, snow, or ice; incorrect configuration (forgot to deflect flaps); high crosswinds; or inability to accelerate adequately. If you are too far down the runway for stopping, you are committed to taking off whether you like it or not – unless you are OK with rolling off the other end. There are no simple formulas for calculating V1, however, because there are too many variables for each aircraft and runway.

As V1 regards stopping distance, its precise speed depends on available runway and ground speed. If you are using a short runway, V1 will be much slower than VR. If you are using a long runway with plenty of stopping distance, V1 will exceed VR and be irrelevant because you will take off beforehand. If you are using a very short runway, V1 is very slow. The following "rules of thumb" are useful although not precise:

- When the runway length is equal to or greater than the jet's combined take-off and landing distances, V1 is equal to or greater than VR, which makes the subject moot. For example, the Longitude's take-off distance is 4,810 feet (1,467 meters), and its landing distance is 3,170 feet (967 meters), for a total distance of 7,980 feet (2,434 meters). If the runway length is 9,000 feet (2,745 meters), V1 exceeds VR, so it does not matter.

Table 1-A

Common V-Speeds for Jets

Name	Abbr	Type
Abort	V1	Min
Rotate	VR	Min
Lift off	V2, VLOF	Min
Initial climb	V4	Max
Flaps retraction	V3	Min
Design maneuvering	VA	Max
Approach target	VAP	Min
Design cruising	VC	Max
Flaps extended	VF, VFE	Max
Max continuous power	VH	Max
Landing gear extended	VLE	Max
Landing gear operating	VLO	Max
Lift off	VLOF	Min
One engine operative	VMC	Min
Never exceed (red line, zone)	VNE	Max
Normal cruising	VNO	Max
Maximum operating	VMO	Max
Rotation	VR	Min
Reference landing	VREF	Min
Stall	VS	Min
Stall landing configuration	VSO	Min
Best angle of climb	VX	Opt
Best rate of climb	VY	Opt
Source: FAR/AIM		

- When the runway length is less than the combined take-off and landing distances, use that percentage of VR. For example, if the runway length is 75 percent of combined take-off and landing distance, use 75 percent of VR. If the runway length in the previous example is 7,000 feet, assume V1 is 88 percent of VR.

V2 and **VLOF** are essentially the same. After raising the nose at VR, you should be able to lift off at V2 or VLOF.

Flaps and landing gear should be operated within **VFE** and **VLO** to avoid damaging them.

V4 is the maximum initial-climb speed while below 2,500 feet AGL.

VMO varies with aircraft and altitudes. The following numbers are generalities:

- Approximately FL250 to FL270, 320 to 325 KIAS.
- Above FL250 to FL270, 451 to 515 KTAS depending on the aircraft.
- Above FL270, 0.77 to 0.90 Mach depending on the aircraft.

Transition between KIAS, KTAS, and Mach usually occurs between FL250 and FL300 depending on wind speed and direction.

Any speed faster than **VMO** for a given aircraft can damage it and should be avoided.

Any speed slower than **VSO** in landing configuration can result in a stall.

VNO is normal cruising speed such as 488 KTAS or 0.85 Mach. The difference between VNO and VMO provides wiggle room when airspeed exceeds VNO during cruising. Every effort should be made to honor VNO at cruising altitude.