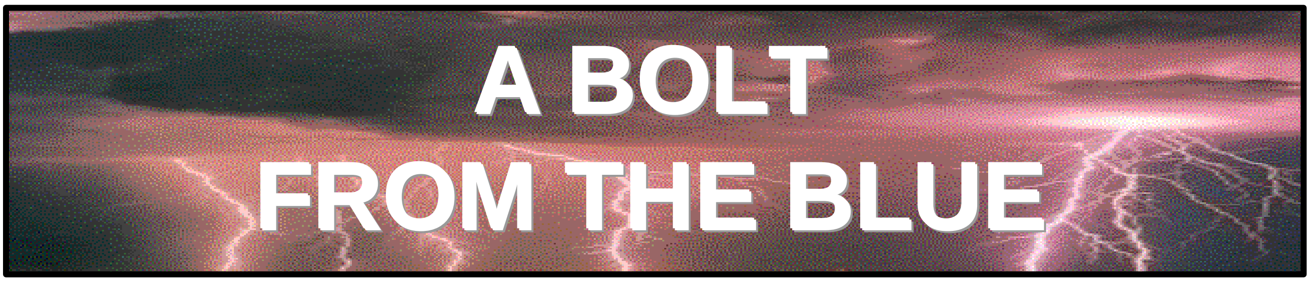

A BOLT FROM THE BLUE

A copy of the original article written by Dan Manningham

Lightning is the personal signature of thunderstorm. It is beautiful, inspiring, spectacular & lethal

Here's the point: Lightning is the product of a thunderstorm. Thunderstorms are hazardous to your health. Stay away from lightning.

But lightning also is dangerous in its own right due to the immense electrical and heat energy involved. The electrical potential just prior to a lightning discharge can be as much as 100 -million volts. The visible bolt can split the air with 20,000 amperes. And if this pure electrical energy isn't adequate to intimidate you, the temperature of the average lightning bolt is twice that of the sun's surface.

Lightning is one of the most powerful phenomena in nature. It is raw energy that can flatten buildings, melt glass and blind eyes. Each bolt also is a vivid and powerful message-one that clearly spells thunderstorm. In all cases, stay away.

It is interesting to know how lightning forms, but that knowledge does not change the basic conclusion. Stay away from lightning whenever you see it. It is dangerously by itself and it is the sign of lethal hazards. Still it is interesting to know how it forms.

Lightning is the result of massive electrification within a thunderstorm. A storm cloud complex is like an electrical generator, producing both positive and negative charges from the motion of ice and water particles within it. Individual electrons are stripped away and congregate together, where they form large charged areas inside the storm. Those charges tend to separate so the top of the thunderstorm develops a large positive charge and the lower layers generate a negative one. These separate charges produce an intense electrical field -a sort of electrical tension just waiting to be released.

The earth normally carries a negative charge compared to the atmosphere. When a thunderstorm passes overhead, however, the negative charge in the cloud repels the negative charge on the ground, as the two like ends of a magnet. This action leaves a wide surface area with a strong positive charge, which follows the thundercloud like a shadow.

As the negative charge in the storm bottom and the positive charge on the ground intensify, they strain to reach each other, illustrating the ever increasing attraction between two opposite magnetic poles.

When that electrical tension (potential) becomes high enough, streamers of energy reach upward from the ground and so called "stepped leaders" reach down from the cloud base forming conductive channels through the air. When the streamers and leaders have created a path of ionized air sufficient to conduct the electrical potential between cloud and ground, a discharge occurs. We see it as lightning.
The intense heat of that visible bolt expands the surrounding air so rapidly that it creates a shock wave not unlike those produced by supersonic flight. That shock wave is perceived as the crack and rumble of thunder.

Lightning bolts travel at about half the speed of light - a mere 90,000 miles per second or so - can reach out dozens of miles and have enough energy to crater the ground, split boulders and ignite forests. And all of this is the normal by-product of a typical thunderstorm.
"Heat lightning" is only a folklore explanation for distant, brilliant lightning on summer nights. "Ball lightning" is a largely unexplained but apparently benign phenomenon. As an airman, you must make the clear and inseparable connection that lightning comes from thunderstorms. And thunderstorms are dangerous.

Every night with lightning is a fearful night and worthy of caution. Fortunately, lightning does not seem to wreak the havoc on aircraft that it does on ground objects. Unfortunately, that fact has been so well broadcast that too many pilots discount the dangers of lightning in flight.
Lightning's effects on aircraft in flight are somewhat different than its effects on surface targets, largely due to lack of grounding, which prevents the current from doing its full potential of damage. Further, metal skinned airplanes produce the so called Faraday Cage by distributing the electrical potential evenly over the metal surface so that occupants and internal components do not receive the sort of high differentials of electricity that cause injury and damage.
Still, several hazards are specific to aircraft in flight from lightning strikes, some of them lethal. A partial list includes fuel explosions, delamination of composite materials (radomes and rotor blades), several forms of damage to electrical components, interruption or alteration of digital programs and minor pinhole damage to metal skins and structures.

Fuel explosions are rare but demonstrably possible. In 1963, lightning ignited the fuel tanks on a Boeing 707, bringing down the airplane and all of its occupants. In 1976, an Iranian Air Force Boeing 747 was lost to the same cause. In other documented incidents an F-4, a T-38, a C-130 and a KC-135 were claimed by lightning. It is somewhat comforting to notice, however, that all of these aircraft were fueled with JP-4 (JET-B), a far more volatile fuel than Jet A. In fact, there is no record of a lightning-induced fuel explosion in any aircraft fueled exclusively with Jet A.
There is one apparent loss of an airplane using Avgas -a Lockheed Constellation in the 1950s -but that would have been far different fuel than the 100 LL and 80 octane currently used.
Incidentally, the worst possible mixture may be a combination of Jet fuel and gasoline, as would occur in those rare instances when a turbine powered aircraft used some gasoline in the absence of jet fuel. That combination is volatile. If you must move an aircraft with a mix of gas and jet fuel, be absolutely certain there is no thunderstorm activity anywhere in the planned route.

Jet engines have been snuffed out by the "plasma" effect of lightning at turbine inlets. Engines that flame out from this should readily restart, but there's always the risk of damage to electrical components, which, of course, includes the engine ignition. Piston engines can suffer ignition damage that-in the worst case-can cause the engine to fail, perhaps not allowing a restart.
Composite materials introduce a different set of problems because they are not conductors and therefore do not produce the Faraday Cage effect. Composite radomes are normally well grounded to the airframe to prevent damage from lightning strikes, but many radomes have been splintered by direct hits. Likewise, rotor blades (tail and main) have experienced massive delamination from the extraordinary heat associated with any lightning strike. If your airplane is built with composite components, you can be sure that certification standards have taken that into account.

Yet, you also should know that not everything is known about composites -or lightning-so be sure to avoid any area of visible discharges.
Magnetic compasses are susceptible to lightning strikes and can suffer permanent damage. Check compasses and compass systems after any strike or discharge.
Electrical systems and electron ic components always have been susceptible to lightning damage, but newer components that require computer software introduce previously unknown failure modes. Such components routinely are packaged and mounted to minimize the risk of lightning damage, but it only takes one errant electron to interrupt a software program. Simpler, analogue components can suffer too-from arcing, welding, melting and other internal damage. After any lightning strike or static discharge, be sure to examine circuit breaker panels for popped breakers.
The massive heat energy of a lightning strike can -and often does melt small holes in aluminum structures. Such pinholes normally are insignificant, but any airplane struck by lightning should be inspected by a mechanic prior to the next flight.

The intense light produced by a strike can cause temporary blindness. There appears to be no record of a pilot being truly incapacitated by lightning, but many have suffered brief visual impairment from the flash. If you have any reason to suspect nearby lightning, turn all cockpit lights to high and consider wearing sunglasses to protect your eyes from the flash.
Lightning is such intense energy that it is infeasible to be fully protected from all of its possible effects. Airplanes in flight enjoy considerable natural protection due to the Faraday Cage, so most lightning strikes do little more than trip a circuit breaker or two. Nevertheless, it can wreak damage, and accordingly, you should avoid thunderstorms diligently.
Traditional wisdom has emphasized the risks of lightning strike in thunderstorms near the freezing level. Recent research by NASA, employing a specially instrumented F-106B, has produced somewhat different information. That airplane made 419 thunderstorm penetrations and received hundreds of lightning strikes. Following are some of the statistics produced.

- Mean strike altitude was 28,400 feet, with many strikes at the 40,000 foot level.
- Mean strike temperature was -32°C.
- Peak strike rates occurred between -40°C and -45°C, in contrast to the traditional expectations at 0°C.
- Lightning strikes were encountered at virtually all altitudes and temperatures, usually where the relative turbulence and precipitation intensities were negligible.

The irony is that you are more s usceptible to a lightning strike when turbulence is light. Inflight lightning avoidance is closely associated with thunderstorm avoidance. Wide detours of any Level 2 or higher returns are the best procedure. When there is any doubt, the 180 -degree turn is still technologically correct, even in this digital age.
Be aware that lightning (as is the case with hail) can damage aircraft five miles or more from the extreme sides of a developed thunderstorm. And do not try to judge the intensity of a storm by its height or breadth. In one tragic accident, a "small" thunderstorm only 23,000 feet high with a radar core slightly wider than a mile shook a Lockheed L-1011 from the air.
On the ground, never approach an airplane during a thunderstorm. You may provid e the grounding that is otherwise lacking. If you are in the cockpit, do not try to communicate to the ground through a wired handset, and stay in the airplane until the storm has passed. Also, avoid the wide -open spaces of an airport during a thundersto rm, since lightning is often attracted to the highest object meaning you in this case.

Lightning may seem as a "bolt from the blue," but it is actually a bolt from the cumulus. Accordingly, routine avoidance of thunderstorms will provide you with all of the protection you need.