

# STEALTH: THE ART OF INVISIBILITY

UNITED AIR FORCE

The future is bright, the future is stealth

***The philosophy of stealth is simple: if they cannot see you, they cannot attack you. This starts with basic things such as camouflage painting and noise reduction. Stealth technology takes 'not being seen' to the next level with radar absorbing materials, complicated shapes and reduced heat emission. All this to remain hidden from the enemy.***

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## HISTORY

The concept of stealth is rather old; the first time camouflage was used in warfare dates back to the 17<sup>th</sup> century. It was first applied on aircraft during the Second World War, the RAF built yellow lights on their aircrafts. Increasing the light emitted from the lower side of the aircraft made it harder to spot in daylight, a big advantage when fighting German U-boats. Flying higher and faster was also a simple technique to remain hidden from enemy troops.

When radar was developed, stealth entered a new phase; not being seen changed into not being detected. During the Second World War both parties started to develop radar jamming devices, to get the advantage in aerial battles. The British thought of reducing the detectability of their aircraft and created the well-known 'De Havilland Mosquito', which was a bomber built with a wooden exterior. Wood reflects less of the radiation

used for radar. This can be considered an early version of RAM: Radar Absorbing Material. The Germans started developing radar absorbing paint since the allies had advanced radar equipment. However, this paint was based on ferrite and was thus too heavy for aviation, though it was very useful on their U-boats.

After the war the British and American aircraft developers started to do research on reducing the radar cross sectional area (RCS). They discovered that flying wings had good RCS reducing properties, making them harder to spot with radar. This resulted in the production of the U2 and the SR-71. For the SR-71 they combined this shape with an incredible speed and altitude to further reduce the detection possibility. Both were also covered with a special paint which had RAM properties.

Several years later the Americans found a twenty year old paper by a Russian scientist named Pyotr Ufimtsev, which was

all about reducing the reflected radar by implementing flat surfaces and irregular angles. This would scatter the radar instead of returning it, and this theory was used to design the F117. This design was called "the hopeless diamond" by its designers due to the shape which was not very aerodynamic. This was the first step into stealth aviation as it is known today.

## CONCEPT

The concept of stealth is thus very simple, namely making it hard to be detected by the enemy therefore giving you the advantage. Several strategies are used to achieve this stealthiness.

A way to remain unseen is to absorb most of the energy of the emitted electromagnetic waves instead of reflecting those waves back to the radar. This can be done by building the aircraft from a material that has electrical properties close to that of the free space. In this case the waves will penetrate through the material

instead of being reflected. If an electromagnetic wave has less energy than the material can absorb, this wave will be fully absorbed in the material. This sounds like a foolproof plan, but unfortunately not all systems, such as an engine, can be built from such a material.

Another solution to be 'undetectable' is to minimize the size of the aircraft's radar image, which was already stated as the radar cross section. This means that the shape of the aircraft is adjusted to reduce the reflection of the waves from the direction the radiation came from. The radar cross section is an indication of the amount of energy reflected back to the radar source. That is the reason why all of the surfaces of the aircraft are oddly shaped with flat surfaces, sharp angles and curves with constantly changing radii. The surface will now scatter the electromagnetic waves in all directions instead of back to the radar source. This is one of the reasons why the design of the stealth aircraft differs from the conventional ones.

To keep this radar cross section as low as possible, all systems and payload have to be carried internally. This means the engine, fuel tanks and missiles have to be carried internally, and even the sealing of a hatch has to be well thought out since a small badly designed edge can have a big impact on the RCS. In addition, the joints between the ailerons and flaps are tapered to reduce the RCS, which again scatters the radiation in all directions. Another important consideration for the design is the air inlet for the engine as the turbine blades of the jet engine reflect radar energy. To minimize this effect, the design of the duct can be adapted to be stealthy. Once again absorption materials can be used or an S-shaped duct can be designed to prevent the engine being in a direct line with the emitted waves. It reduces the amount of energy reflected back, though looking from the performance point of view this is not ideal.

Another important factor for stealth capability is to reduce the infrared emission. Infrared radiation is emitted from all sources that contain heat, with the propulsion system as the biggest contributor. This can be reduced by screening off the hot parts of the engines by parts of the airframe. The infrared radiation of an aircraft is mainly caused by the high temperature of the exhaust gas plume. It is very hard to minimize this effect, but it can be reduced by mixing the hot exhaust gas with exactly enough surrounding cold air delivered by the bypass. This also reduces the noise of the engines.

Another source for the emission of infrared is frictional heating, which appears at



Figure 1. Two U.S. Air Force F-15E Strike Eagles and a B-2 Spirit bomber fly in formation over the Pacific Ocean

high velocities. Moreover, reflected and re-emitted sunlight are also sources for this radiation.

However, the solution to reducing the aircraft's signature is shifting the emitted infrared radiation into different wavelengths. The amount of energy for those wavelengths will be further reduced by the atmosphere. Due to this, they are more readily absorbed by CO<sub>2</sub> and water vapours. As a result, it is more difficult to detect the aircraft from a long distance away.

#### DRAWBACKS

Compared to 'normal' aircraft, stealth aircraft have, of course, the big advantage that they can approach the enemy without the risk of being shot down. This is very useful for reconnaissance, attack or secret missions. However stealth airplanes also have some drawbacks: one major drawback is the high cost. Designing, developing, producing and maintaining stealth aircraft is much more expensive than for standard aircraft. Furthermore, stealth aircraft are not as fast and agile as current normal fighter jets, which is no problem for a bomber or a spy plane, but is a serious drawback in a dogfight. Another drawback is the reduced payload, which, as mentioned previously has to be carried internally. This massively reduces the amount of payload, both fuel and weapons, that can be carried while in stealth mode compared to normal planes.

#### FUTURE

One of the best known current projects on stealth is the Joint Strike Fighter, which

will be equipped with the latest stealth technologies. Now that stealth technology is getting more and more advanced it will also be used in other fields of warfare, for example on transport planes, helicopters, ships and tanks. There are also new players getting involved in the game of stealth: India, China and Russia. Russia is currently developing their Light Frontline Fighter (LFS) project with the S-54, India is competing with their Medium Combat Aircraft (MCA) project. This will be a fighter plane without vertical stabilizers, instead they aim to use thrust vectoring. China is designing the J-12, a fighter that will be similar to the F-22. From this one can clearly conclude that stealth is the future of aerial combat, without it you are not even competing. ✈

#### References

Australian Airforce stealth technology: <http://www.ausairpower.net/TE-Stealth.html>

Concept of stealth: <http://www.totalairdominance.50megs.com/articles/stealth.htm>

#### Aviation Department

*The Aviation Department of the Society of Aerospace Engineering Students 'Leonardo da Vinci' fulfills the needs of aviation enthusiasts by organising activities, like lectures and excursion in the Netherlands and abroad.*

