The major reasons why CFRP is proving victorious in defence technology

The manufacture of components for military technology is something of a balancing act because its design and production process is defined by the challenge of finding a perfect balance between the factors of safety, resilience, durability and lightweight construction. Metals like steel and aluminium alloys were long viewed as the answer to the requirements of **defence technology** but ultimately they were not able to resolve the conflicting objectives presented by the aforementioned factors, since safety, durability and strength are typically achieved at the expense of weight. Today however, weight reduction is one of the key requirements of modern developments in defence technology. This explains why innovative fibre composites such as CFRP, aramids [e.g. Kevlar], basalt, aromatic polyesters [Vectran] or PBO [Zylon] are receiving ever more attention from the **arms industry**.

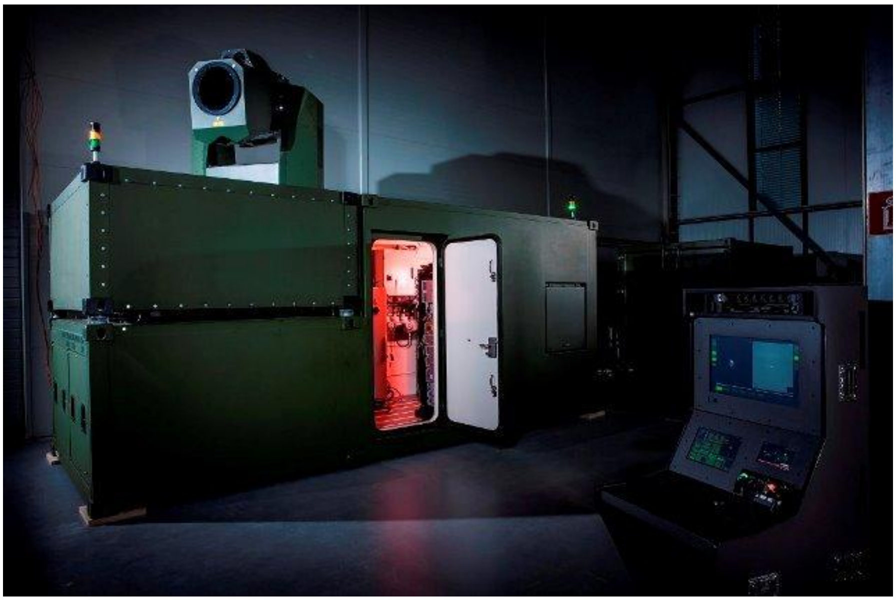


Figure 1: Structural components made of fiber composite materials for high-energy lasers (MBDA Missile Systems)

Leading companies in this sector recognised this trend a long time ago and are already committed to the innovative powers of **extreme lightweight construction**. Above all, the focus is now on structural components made of carbon composite because of their superlative properties. It is easy to explain why it makes perfect sense for the defence technology sector to switch to carbon-based lightweight construction:

CFRP is a genuine lightweight

In motor sports, the advantages of composites have been known for a long time, and have proven themselves in thousands of applications. Using CFRP not only makes it possible to create aerodynamic shapes that are almost impossible to manufacture using other materials and processes, but it also the key to achieving a substantial **reduction in the weight of components and complete units**. Using new solutions made of carbon composite makes it possible, when compared to **aluminium components**, to reduce weight **by up to 50%**. When compared to **steel components** that figure actually rises **up to 80%**. Accordingly, in technical league table terms, CFRP with a **density of 1.5 g/cm^3** is significantly lower than aluminium (2.8 g/cm^3) and steel (7.8 g/cm^3).

Figure 2: Mobility increase through extremely light launcher systems (MBDA Missile Systems)

In defence technology, this material advantage not only benefits equipment components but also general-purpose and reconnaissance vehicles, launchers and pivot-mounted systems as well as platforms: the weight reduction achieved with lightweight components made of carbon composite facilitates faster acceleration, greater agility, higher precision, shorter braking distances and significant savings in terms of fuel costs. In addition, military infrastructure as well as equipment for soldiers is easier to transport and handle. This greatly improves the mobility of combat troops!

CFRP offers enormous design freedom

As highly innovative materials, composites provide greater **construction and design latitude** and more scope for innovation. In contrast to conventional production processes and materials, **complex geometries** such as undercuts are comparatively easy to create using composite fibre technology.

Using CFRP does away with the restrictions imposed by the need for compliance with bending radii or wall thicknesses, as well as with the required use of ribs for reinforcement.

Composites also set new standards in relation to the size of components: With the production of carbon composite components using prepreg-autoclave technology, larger components can be produced than with the precision casting process. This greatly reduces the number of welded seams, areas affected by thermal expansion.

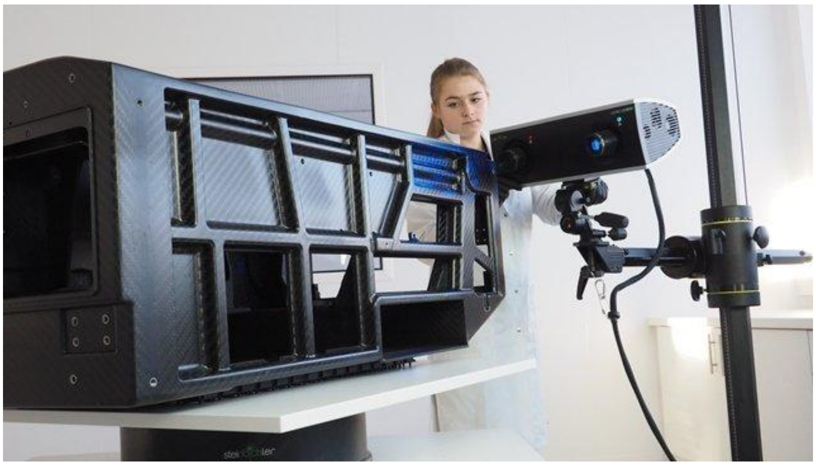


Figure 3: 3D-scanning of a structural component with complex geometry made of CFRP

CFRP proves its ability to stay the course

Fibre composite materials are convincing in terms of more than just their weight – their **resilience and durability** also make them ideal for use in defence technology components: carbon composite is not only four times more resilient than aluminium but it is also characterised by great strength and vibrational resistance, almost negligible thermal expansion (just 10-6*K-1) as well as great resistance to sustained high temperatures and corrosion. This means that composites are perfectly suited to use in environments that are subject to arduous conditions and big temperature fluctuations, as well as for marine components that are in continuous contact with salt water.

The fact that carbon fibre-reinforced plastics are free of the fatigue failure issues that affect aluminium that cause it to crack under endurance loadings, is just one of the further arguments in favour of manufacturing with composites. CFRP is also better able to withstand shelling and gunfire than metal castings. Metal castings are prone to cracks that propagate rapidly around gunshot holes whereas components made of composites are able to prevent component failure, and are relatively easy to repair.

	CFRP-UD	CFRP-Prepreg*	Dural Alu	Unit
Density	1,5	1,56	2,8	g/cm^3
Tensile strength	3400-5400	900-950	350-500	MPa
Compressive strength	450-520	540	300-480	MPa
Bending strength	2050	990-1050	500*	MPa
Tensile modulus	235-358	60-70	75	GPa
Flexural modulus	130	60-62	-	GPa
Elongation at break	1,4-1,7	1,5	<22	%
		*bidirectional fabric plate	*Bending strength pure Al	

Figure 4: The mechanical properties of CFRP in comparison to dural aluminum

CFRP is resistant to chemicals

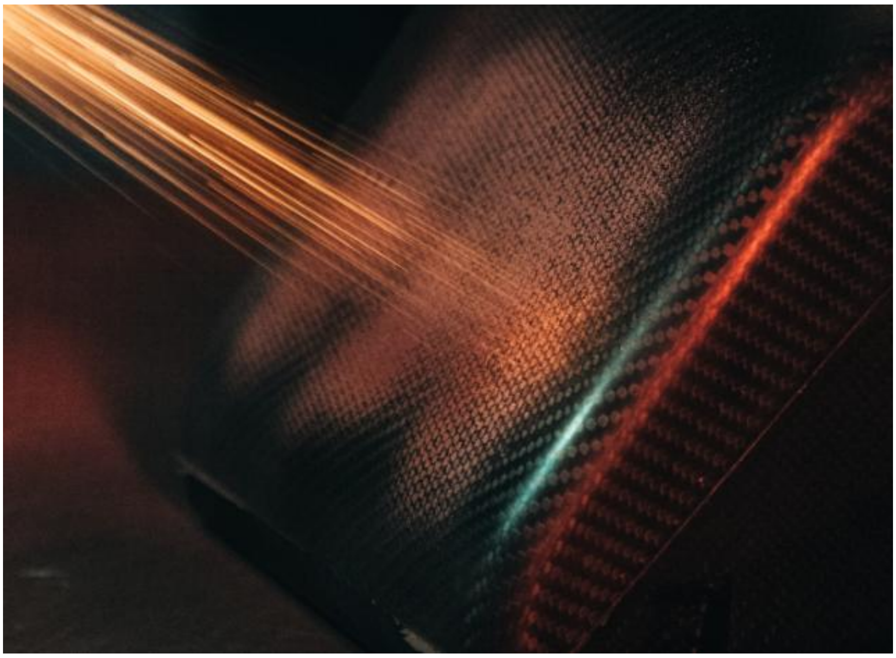
The chemical resistance of this material also adds to its credentials for use in defence technology. Carbon composite is therefore to a very large extent **resistant to aggressive chemicals and corrosion** which extends the service life of a vast array of different military components. Carbon fibre-reinforced plastics are also resistant to corrosive substances such as phosphoric and acetic acid, dry sulphur dioxide gas, methanol, ethanol, chloroform, mineral oils, benzene and hydrochloric acid.

CFRP is also biocompatible. The term **biocompatibility** designates the absence of any adverse impact of materials on creatures and their environment. This property is especially significant in relation to components that are worn close to the body by combat troops.

CFRP protects against electromagnetic radiation

With carbon fibre, a shielding effect can be achieved, causing a **reduction in radiation levels** of around 95.5% as well as cutting emissions from 50 to 0.25 dB. For this reason, CFRP can be used to shield electronic modules as well as personnel from electromagnetic fields. To further improve this shielding effect, special surface coatings are used - known as EMC protective coatings -. These are applied using specialist EMC protective paints or thermal spraying.

Figure 5: Applying an EMC protective layer to a carbon composite component by thermal spraying



CFRP has been tried and tested thoroughly

In high-tech sectors such as motor racing, aviation and in high-end applications in the automotive industry, CFRP is already considered to be the key material of the 21st century. Innovative companies in the defence technology sector can therefore draw on a broad **range of experiential data** to create products for applications that face similar demands on their staying power. They can draw on knowledge relating to lightweight, geometrically stable components with good fire-resistant properties from civil aviation, coating know-how from the maritime sector or expertise relating to safety-critical structural components from the world of motor racing. Enormous potential for innovation opens up for defence technology through the adoption of tried and tested design and production processes.

CFRP makes sound financial sense

Although composites are viewed as expensive materials, McKinsey believes that by 2030 the cost differential between carbon and aluminium will almost have disappeared. And already today, it is possible to manufacture carbon composite components for prototypes and short production runs so economically that the choice of material almost ceases to be a factor: now that the levels of investment needed for mould design and construction are substantially lower, coupled with the reduction in

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rework costs for parts that simply drop out of their moulds, in terms of cost, composites are now a genuine technical alternative to aluminium and precision casting.

When you include factors such as service life, durability and weight advantages, it makes perfectly sound financial sense to switch to fibre composite materials for defence technology components that have to withstand enormous stresses and strains.

CFRP is a true all-rounder

For some time now, thanks to the properties described above, the defence technology sector has been enjoying the benefits of CFRP as an innovative material. Another consequence of these properties is that the material can be used across a broad range of applications in the defence technology sector. From platforms and structures for rocket and launcher systems to components for military transporters as well as equipment for soldiers and military infrastructure - CFRP has a versatile range of uses. The universal range of applications for carbon composite is another positive reason in favour of using this material in defence technology.

Figure 6: The properties of CFRP enable the material to be used in a variety of applications in defense technology

Summary: Carbon is advancing strongly

The benefits of composite materials speak for themselves and, after decades of successful applications in high-tech sectors, they are now gaining ground in defence technology. Through a combination of designs optimised for the use of fibre and in-depth manufacturing expertise, CFRP can do more than hold its own against steel and aluminium alloys, once and for all resolving the conflicting targets of safety, resilience, durability and lightweight construction, and doing so in an innovative manner.