TitanWeave™
A revolution in lightweight, penetration resistant composites
TitanWeave™ is a patented technology developed by QinetiQ that relies on the efficient, controlled introduction of a Shape Memory Alloy (SMA) into a fibre reinforced plastic. It provides cost-effective, lightweight and penetration resistant composites.

**Challenge**

With OEMs and airlines constantly striving to decrease emissions and lower costs, utilising technologies that reduce mass and manufacturing cost is increasingly important. Fibre reinforced polymer (FRP) composites offer the required high strength, low mass material solution, and are starting to be used widely across the aerospace industry. However, optimising the use of FRPs materials remains a challenge.

Aircraft are operating in environments where foreign object impact (FOI) threats are considerable; for example, it’s estimated that one in every 1,000 UK flights is subjected to a bird strike. The relatively poor impact performance of traditional fibre reinforced plastics necessitates the design of far heavier FRP components to ensure post-impact structural integrity.

**Solution**

To address this challenge, QinetiQ has developed TitanWeave™, an innovative patented process that combines fibre reinforced plastics with shape memory alloy (SMA), enabling the optimised use of composites and potentially reducing the mass of current composite components by up to 40%.

**Figure 1: TitanWeave™ close-up**

![TitanWeave™ close-up](image)

Our TitanWeave™ technology combines SMA wire, which can withstand large amounts of elastic and plastic deformation at high stresses, with traditional FRPs. The SMA element provides the enhanced ability to absorb energy before structural penetration, presenting a significant step change in FRP impact performance. The selection, geometry and architecture of the SMAs are controlled to ensure that the high specifications of the FRP are retained.

Additionally, TitanWeave™ is a multifunctional material; currently, composite structures that require protection against environmental effects or lightning strike typically use a parasitic material added to the surface of the structure, incurring additional cost and mass. Incorporating TitanWeave™ technology can eliminate the need for parasitic layers, offering further cost and mass reduction, and simplifying traditional manufacturing techniques.

**Key Benefits**

- Three-fold increase in penetration resistance
- Facilitates greater use of composite materials
- Multifunctional material for impact energy absorption and additional functionality, e.g. lightning strike protection
- Enables optimum use of composites, reducing mass and cost
Case study

Foreign Object Damage (FOD), such as bird strike, hail stones, tyre, stone, or engine debris, remains a real threat to aircraft because these events generate severe and multiple impact scenarios. To characterise the performance of TitanWeave™ against this threat, a series of leading edge D-nose sections were assessed against high speed impacts, simulating FOD. Two very different impactors were assessed; the first was a steel ball ‘hard body’ impactor, representative of threats such as runway debris; the second was a gelatine ball, a highly deformable ‘soft body’ impactor, comparable to bird strikes (see Figure 2 below).

Figure 2: Assessing TitanWeave™ against the impact of FOD

A series of leading edges were manufactured from a combination of pre-impregnated 5HS carbon and a matched TitanWeave™ (SMA reinforced 5HS carbon prepreg). Various lay-ups of the baseline and TitanWeave™ plies were used to generate leading edges with a volume fraction of SMA reinforcement ranging from 0-12%. The total number of plies used in each leading edge was varied to enable the total mass of the structure to be controlled.

The leading edges were manufactured using a 1.2m width fabric with a 0/90 lay-up. No notable difference was observed when handling the TitanWeave™ plies compared to the baseline plies. Furthermore, the presence of the SMA had no effect on the various stages of de-bulking and final autoclave consolidation.

The leading edge structures were subjected to impact tests of 40-250ms⁻¹, simulating both hard and soft body FOD impacts of 20 to 120 Joules. In all cases the presence of SMA in the structure significantly increased the perforation energy.

Figure 3 below shows two of the leading edge structures with the same mass: a baseline carbon composite and a TitanWeave™ leading edge. The steel ball penetrates straight through the baseline structure and continues with significant velocity (52.9 m/s) towards the back-plate. However, in the SMA reinforced leading edge, the structure locally deflects to absorb the energy from the ball and ejects it back towards the firing cylinder.

Figure 3: Leading edge structures (equal mass) impacted with steel ball at 75ms⁻¹

The results of the study showed that the presence of approximately 10 volume percent of SMA delivered up to 212% improvement in energy absorption per unit mass. This demonstrates that SMA reinforced composite materials could be included in a typical leading edge skin, enabling a significant reduction in weight for a given level of impact damage protection against bird strike or other FOD.

Conclusion

TitanWeave™ technology can provide benefit wherever impact poses a threat, but particularly where structural mass is driven by the need to resist impact threats during service. The mass of these structures could be considerably reduced using TitanWeave™, without cost increase.
Collaborating with QinetiQ

At QinetiQ we bring organisations and people together to provide innovative solutions to real world problems, creating customer advantage.

Working with our partners and customers, we collaborate widely, working in partnership, listening hard and thinking through what customers need. Building trusted partnerships, we are helping customers anticipate and shape future requirements adding value and future advantage.

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