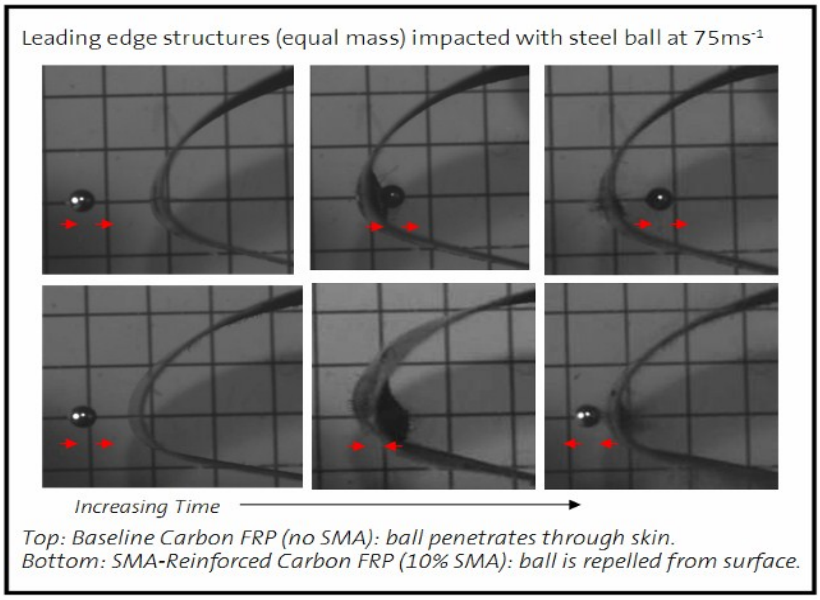
High Energy Absorbing Composites

The requirements for future highly loaded aerospace composites structures are challenging. Low material and manufacturing cost as well as low mass are increasingly important as equipment manufacturers and airlines strive to reduce emissions and lower costs (and price) per passenger mile. Fibre reinforced polymer (FRP) composites have the potential to meet these challenges, with improvements in impact performance and damage tolerance developed at QinetiQ. The solution on offer at QinetiQ is a commercially viable materials technology which relies on the efficient, controlled introduction of a Shape Memory Alloy (SMA); a special class of functional metallics which can undergo large amounts of elastic and plastic deformation, at high stresses. The SMA wire selection, geometry and architecture, as well as the weaving process, are all designed to ensure that the high specific properties of the FRP are maintained, whilst the SMA provides significantly enhanced potential to absorb energy before structural penetration.

QinetiQ's research effort has been targeted at mass, cost and performance optimisation with the materials supply chain involved in the developments.



Top: Baseline Carbon FRP (no SMA): ball penetrates through skin.
Bottom: SMA-Reinforced Carbon FRP (10% SMA): ball is repelled from surface.

Material assessment

High energy threats, such as birdstrike, remain a severe hazard to aircraft because impact events can produce multiple impact scenarios with catastrophic results. To demonstrate the improvements SMA-reinforced FRP can offer a series of leading edge structures were assessed. The structures contain varying volume fractions of SMA reinforcement and were tested under impact so that the influence of the SMA on the impact performance could be compared, for equivalent mass and thickness.

The leading edge structures were subjected to Foreign Object Damage (FOD) simulating both hard and soft body projectiles which were representative of impact tests from 40 to 250ms^{-1}. The results of the study showed that the presence of only *10% by volume* SMA in the structure delivered up to *217% improvement in energy absorption per unit mass, i.e. more than 3 times stronger.*

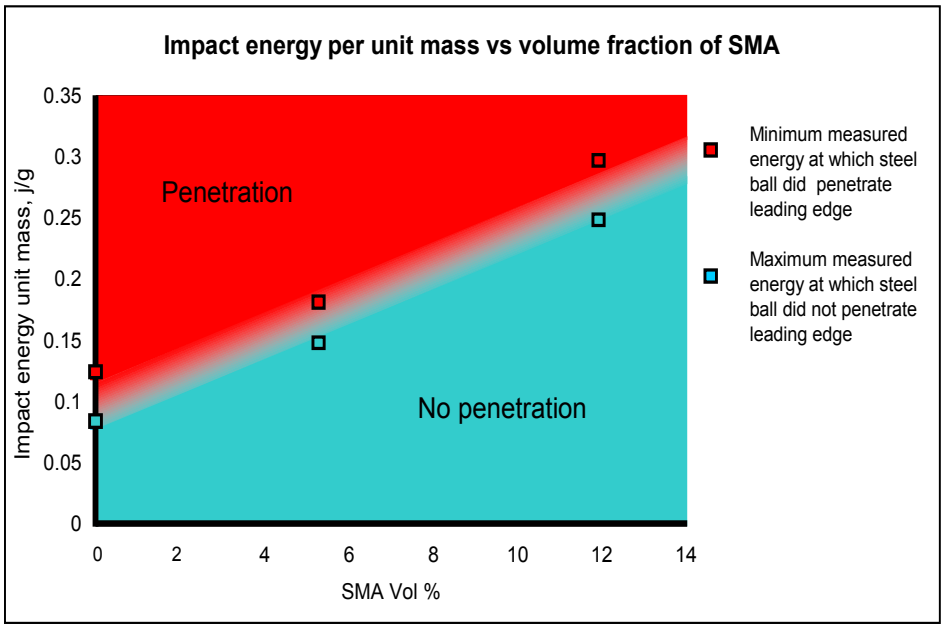
Multifunctional applications

Composite structures often need to be protected against environmental effects such as ice build up, high intensity electromagnetic radiation and lightning strike. Typically a parasitic material is added to the surface of the structure, incurring additional cost, mass and complexity. QinetiQ has completed lightning strike assessments, at highest threat level, demonstrating that using SMA-reinforced material eliminates the need for these parasitic layers. Just *6% by volume SMA* delivers protection to an *equivalent level* of commercially available lightning protection products.

Into Use

In summary the SMA-reinforced material could be used anywhere that impact poses a threat. Designs can be tailored and optimised such that benefit is delivered to specific areas where structural mass is driven by the need to resist impact threats during service.

Many leading edge panels are significantly heavier than required, due entirely to the need to resist penetrative impact threats. QinetiQ has shown that mass can be significantly reduced using SMA reinforcement, without any cost increase. The multifunctional properties of SMAs suggest further mass and cost benefits are possible if all requirements (e.g. birdstrike, lightning strike, ice accumulation etc.) are also considered.



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