

IMPSHIELDA, B & C

Impact shield A, B & C

State of the art – Background

Advisory Council for Aeronautical Research in Europe (ACARE) have set out a goal of reducing fuel consumption per passenger by 50% from the levels in 2000 by 2020. In the clean sky partnership program fuel saving and thus weight savings are a central issue towards achieving these ACARE goals. One accepted approach to achieving these goals is widespread use of composite materials in aircraft. Another approach is the use of uncontained engines mounted close to the fuselage, as suggested in the Clean Sky Smart Fixed Wing Aircraft (SFWA) initiative. However, impact damage on composite structures is a serious concern in the aircraft industry. Failure of rotating aircraft engine components may result in fragments thrown outwards at high velocity. Penetration of pressurised sections of the fuselage may obviously be catastrophic and have to be avoided at any cost. To prevent this damage occurring impact shielding has to be integrated with the fuselage and other structures at risk. The combination of the latest development in quality of these materials and the fact that they meet the environment requirement as well as an innovative ballistic design takes the proposed shield concept beyond the state of the art.

Objectives

The main objective of the project was to design shielding and to manufacture the associated composite panels for the purpose of assessment of their ballistic performance. The panels were delivered into the IMPTEST project for physical testing to find the V_{50} for the three different designs and three different projectiles. The three concepts were using well established high performance fibres and manufacturing methods making it fit the requirements of medium to high maturity level and low manufacturing costs stated in the call. The issues to be addressed from the proposal were what concepts are most likely to be successful shields and how will these shields be manufactured.

Description of work

The work in IMPSHIELD A, B and C was done simultaneously, as was the testing of the different concepts in the IMPTEST project. To get a better overview of the entire IMPSHIELD project and how the delivering for all three projects was managed, all three projects were presented together.

The work for the IMPSHIELD projects was divided into four work packages. These were:

- WP 1 – Project management
- WP 2 – Shield Design
- WP 3 – Shield Manufacturing
- WP 4 – Aircraft Integration and Environment

The aims were fulfilled by firstly designing the shield in **WP2** based on the concept layout. The actual design required modelling of different structural dimensions using material data provided by some initial testing of the composite material used. This modelling optimised the structural dimension and improved the successful shielding structure.

After the design was established the project continued with the most comprehensive work package, shield manufacturing in **WP3**. This started with some initial tests of manufacturing laminates at SICOMP using the fibres together with epoxy resin film, prepreg and a thermoset powder to establishing process parameters such as temperature and pressure for these particular composites.

The three different panels(A, B and C) for phase one testing were all hot pressed and manufactured in three different thicknesses to match the three projectiles. At the mid-term review in January 2015 it was decided that the project were to continue with the B- and C-panels for more detailed testing. The manufacturing processes for the panels were the same as for phase one. Most of the panels were delivered to Imperial College in London for phase two testing, but five of each was kept for ageing. A literature review on the effects of environment of the materials was done (**WP4**) and led to the ageing conditions. The panels were aged in an environmental chamber for almost two month, monitoring the weight gain approximately ever 100th hour. After the ageing process, the panels were delivered to London for testing. Giving all aims fulfilled.

Results

Three different panels were designed and manufactured in the IMPSHIELD projects to be used in the IMPTEST project (also coordinated by SICOMP) to find the V_{50} for the different panel designs and projectiles, using a gas gun at Imperial College London.

The three different panels were all hot pressed and manufactured in three different thicknesses to match the three projectiles.

IMPSHIELD A ended up as a hot pressed S2-glass laminate with a thermoset powder matrix. The powder made it possible to get a resin starved area acting as the ballistic shield with a rigid frame with more resin.

IMPSHIELD B was a hot pressed UHMWPE prepreg laminate with a PUR matrix with a uniform fibre fraction.

IMPSHIELD C was a hot pressed ARAMID with an epoxy resin film, allowing a resin starved area acting as the ballistic shield with a rigid frame with more resin.

a) Timeline & main milestones

The project started in April 2013 with a kick-off meeting (**MS1**) together with the IMPTEST project since the projects were so closely connected to each other. At the meeting it was also agreed about coordinating the project meetings together during the projects. A detailed work plan was created (**MS2**) and the consortium agreed about the environmental condition requirements (**MS3**) and the design specification was established (**MS4**). The numerical design phase followed during the summer and autumn with some data from material tests (**MS5**). The output from the design (**MS6** and **MS8**) gave input for testing the key concepts regarding manufacturing (**MS7**). Then the final design specifications could be set (**MS9**) and the panel manufacturing started in the spring of 2014 and panels were delivered during the summer and autumn. At the delayed mid-term review (**MS10**) in January 2015 the work ahead was decided. During the spring the remaining panels for phase two and ageing were manufactured. The ageing process

was based on the environmental factors affecting the shields (**MS11**). All shields were delivered to IMPTEST before the IMPTEST project end date, 31th of July 2015.

b) Environmental benefits

The aim of the Clean Sky initiative is to provide radically greener air transport based on novel concepts for engines and aircraft design. In this way Clean Sky is expected to provide major steps towards the environmental goals for aviation in 2020 set out by ACARE. The impact shields designed within the IMPSHIELD projects will provide the basis for the shielding structures that will be incorporated in aircraft structures and will be useful for the use of larger and more efficient uncontained engines.

c) Dissemination / exploitation of results

Since the IMPSHIELD projects main objective was to provide shields for the IMPTEST project to get the ballistic data for the different shields and projectiles all external dissemination comes from IMPTEST.

d) Communication

There is only one beneficiary in the project, but a sub-contractor where the communication has been working well. Since SICOMP is coordinating both IMPSHIELD and IMPTEST the contact between the two projects has also been good and the joint communication with the Task Manager has also been working well. The communication, help and support from Project Support Officer Alice DARMANDIEU has been excellent.

Figures of the tree different shielding concepts

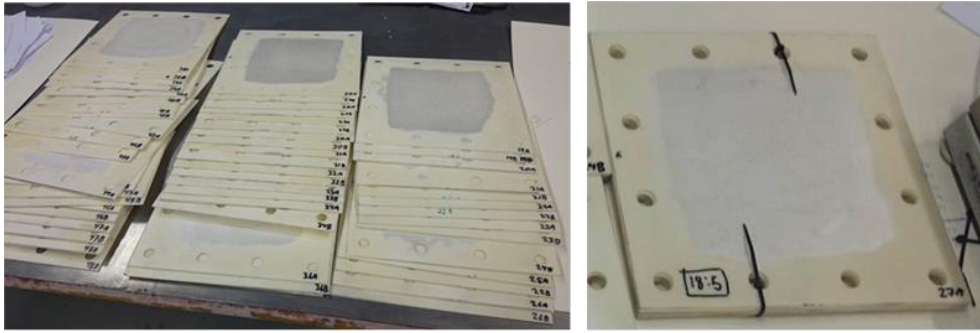


Figure 1, IMPSHIELD A, S2-glass and thermoset powder matrix.

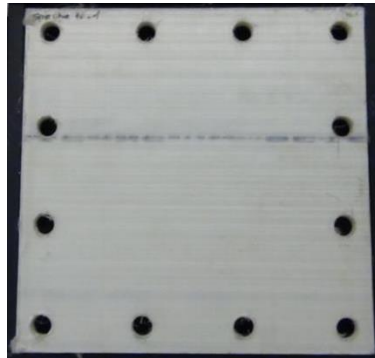


Figure 2, IMPSHIELD B, UHMWPE/PUR prepreg

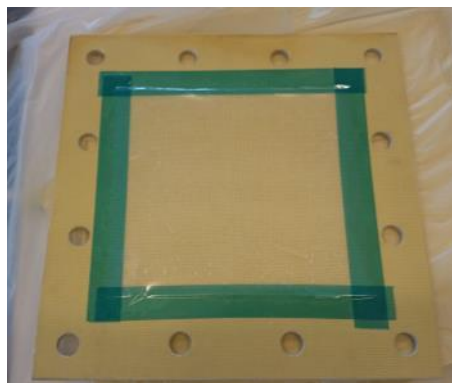


Figure 3, IMPSHIELD C, Aramid and epoxy resin film

Project Summary

Acronym:	IMPSHIELDA, IMPSHIELDB, IMPSHIELDC
Name of proposal:	Impact Shield A, Impact Shield B, Impact Shield C
Involved ITD	Smart Fixed Wing Aircraft ITD
Grant Agreement:	296688, 296689, 296691
Instrument:	Clean Sky
Total Cost:	EUR 70,000 + 90,000.00 + 90,000.00 = EUR 250,000.00
Clean Sky contribution:	EUR 52,499.00 + 67,499.00 + 67,499.00 = EUR 187,497.00
Call:	SP1-JT1-CS-2011-01
Starting date:	1 st of April 2013
Ending date:	31 st of July 2015
Duration:	28 Month
Coordinator contact details:	Kenneth Strand, Swerea SICOMP AB kenneth.strand@swerea.se
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Participating members	Sub-contractor Imperial College London Consultants (ICON)