# Socio-economic benefits from ESA Technology Transfers (Pilot)


## Case Study 2

CiTD: Future aircraft composite firewall

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# **Lighter, better, faster, cheaper:** Using space heritage to enhance next generation aircraft

Protecting satellites during their ascent to space requires significant investment and development of state-of-the-art technology. **A new composite bulkhead concept, an important part of the shell protecting satellites onboard ESA's Ariane 5 and 6 launch vehicles, is being redeveloped for use aboard aircraft on Earth by Airbus Defence & Space.** The improvements realised on the space payload membrane have proven to be significant and there is lots of potential for translating those benefits for the aviation industry on Earth. Fitted in the rear tail cone of the aircraft, the firewall bulkhead serves to contain a potential fire originated by the Auxiliary Power Unit inside the designated area, enabling a safe flight.

In commercial aircraft, there are several walls, firewalls or bulkheads subjected to different pressures at both sides. The best shape for these walls or bulkheads in terms of architecture of the plane is a flat surface. However, the stiffness and strength of this shape form is insufficient without further reinforcement of the structures, either by making them curved to better support the pressure and/or through the use of stiffeners.

The previous bulkhead design used on launchers, made with flexible materials reinforced by aluminium rings, is very challenging to use. **The existing A320 firewall is produced using titanium and requires several elements, including a titanium sheet, stiffeners, and out of plane struts, all of which adds crucial mass to the aircraft and results in a long assembly process.** These flexible membranes are complicated to manipulate and integrate, as a result of the many parts, and so there exists a clear opportunity for improvement.

## Space technology brought down to Earth ...

Spanish structural specialist CiTD work across both aviation and space. CiTD collaborated in the design of the Ariane 5 bulkhead with Airbus Defence and Space (Spain) and worked with ESA's Technology Transfer and Patent Office (TTPO) to probe the feasibility of transferring the design from the launcher to aircraft.

CiTD knew the 'crumpled petal' design had potential for wider use and with their contacts at Airbus, developed the firewall for commercial aviation as well. With Airbus they evaluated the solution of a solid petal shape (carbon fibre) that would not buckle under different pressures.

"The task of this bulkhead aboard Ariane 5 is to protect the satellite from the launcher exhaust, dust or overpressure from the launcher stage below it. **We came up with an effective wavy shape–stiff and self-supporting, as well as pressure resistant.** It flew for the first-time aboard Ariane 5 in 2020 and is now the baseline for this launcher, as well as the upcoming Ariane 6."

*Marta García Cosío, CiTD*

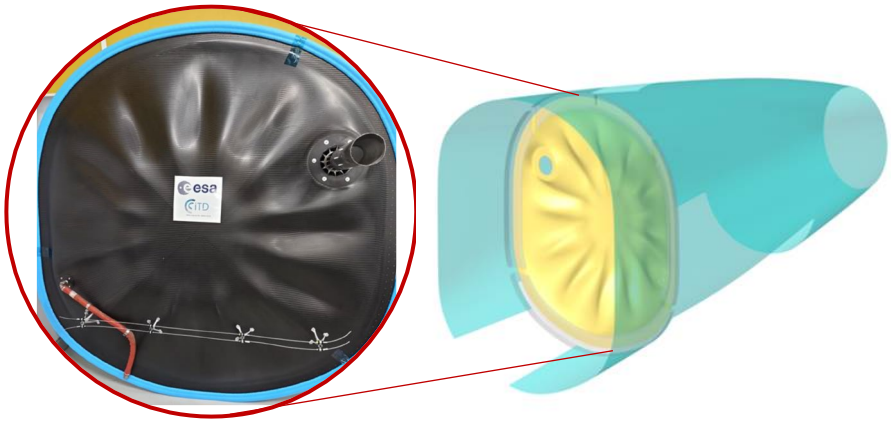
**The new composite bulkhead concept uses an optimised, rigid, Carbon-Fibre Reinforced Polymer (CFRP) laminate.** Strong yet light, CFRP is made by carbon fibre reinforced polymer threaded through it for robustness; following a similar approach to steel-reinforced concrete. It can be moulded into complex rigid shapes, such as the aerodynamic bodies of Formula One cars, or the wingtips and noses of many modern aircraft–in addition to the solid rocket motor casings of Europe's Ariane 6.

Airbus, as the Original Equipment Manufacturer (OEM) on the project, is excited by the potential of a new firewall concept and its future potential. Airbus is updating and producing new solutions, each with different shapes and technologies. Airbus's Research and Technology team is supporting CiTD to check the feasibility of the new firewall proposal by evaluating the benefits and drawbacks.

**"This new CFRP firewall is a very promising revolutionary structural concept** that could be considered for the next generation of aircraft."

*Javier Vazquez, Airbus Research and Technology*

**New Carbon-Fibre Reinforced Polymer (CFRP) firewall**[1]



## Potential for significant socio-economic benefits

There are several socio-economic benefits that have already been realised in the initial stages of the technology development, with promise of many larger, global benefits to come as the new firewall is further developed and becomes available to a wide range of users.

## Developing an innovative firewall

### *Commercial opportunities*

CiTD are confident that a new, innovative firewall for future aircraft presents a great opportunity for them to show their capabilities and help the company grow. CiTD may only end up providing the firewall to a singular client, however the size of the opportunity is significant. CiTD could become a supplier for Airbus Tier 1 subcontractors since it will be able to offer a lower price with high quality. The new firewall is a non-configurable part, enabling it to be adopted for use across the full series of Airbus aircraft; serving an existing Airbus high production rate of 50-60 aircraft manufactured per month, which is expected to rise in the future.

Boeing and IAI have also shown interest about the concept, whilst the defence industry has shown their interest, via companies including MBDA and Terranova.

The source of revenue for CiTD offering this product will be generated by different activities:

Product sales: if the customer buys the final product
Licensing fees due to patent: if the customer manufactures the part by themselves
Engineering service: for any adaptations in the shape due to a change in interfaces
New project development: the creation of new products for future airplanes
Maintenance service fee: in case repairs are needed on the CFRP shape

[1] CFRP Airplane Bulkhead firewall – Proof of Concept – Final Report

### *Job creation*

For CiTD, future success of the concept would create new jobs and provide a new source of jobs for the Spanish economy.

### *Potential for future applications*

The concept can be scaled up to other pressure bulkheads (due to the similar concave spherical shape) which isolates the pressurised cabin. Read more about future applications in the "future benefits from scaling concept to other aircraft parts" section.

## Providing an array of benefits for Airbus and others

**This new firewall brings several significant improvements in terms of mass saving, controlled volume, time and cost assembly, and ease of manufacturing and integration process.** Substituting the long assembly process with a single part helps save mass, reduces the occupied volume thanks to the elimination of the struts, simplifies the entire supply chain and reduces the overall manufacturing time of each aircraft.

### *Higher quality*

The pressure firewall developed by CiTD is made in one part of CFRP thin laminate with corrugated shape to increase the stiffness and stability of the part. Post buckling behaviour prevents collapse of the structure and resistance is very high. The deformation of the part is also very low.

### *Mass saving*

The result of this new singular part, with no subassemblies needed, is that **mass is 30% lower than the titanium firewall baseline solution.**

Mass saving is critical for an aircraft as it enables fuel savings and free volume. Improving the free volume on an aircraft allows for greater accessibility and loading capability—both of which are key elements for the aeronautical sector.

### *Reduced integration time and cost*

The current firewall is a flat piece of titanium with hundreds of fasteners and stiffeners needed to stop it collapsing. The current assembly process entails a long installation process, which requires a lot of manual labour. Swapping this with a single piece of composite, made to exactly the right shape with all necessary holes for power and fuel conduits and fire sensors, saves hours of time and could have a big impact for Airbus and others when it comes to integrating dozens of aircraft per month.

Faster assembly of planes results in **lead time and cost reductions** in line with Airbus objectives.

Given the expected growth of the aeronautical sector, with aircraft traffic growing at 4.3% annually and a forecasted 39,000 new aircraft being developed over the next 20 years, the application of the rigid membrane concept in commercial aviation represents a timely development. **As of 2019, Airbus has a backlog of 7,577 planes, as it accumulates almost as many new orders a year as it delivers.** Covid-19 has also had an impact on Airbus A320 production numbers.

### *Manufacturing automatisation*

The reduction in the number of parts reduces the complexity and thereby enables a greater ability to automate parts of the manufacturing process. The simplicity of the product is a big benefit, which extends to further benefits across the full product-cycle such as simplicity on the material

purchasing and logistics, and on manufacturing operations with reduced assembly. Compression moulding will also present benefits on time and cost of the parts, enabling serial production.

### *Reduced costs*

Considering the number of units delivered by Airbus every year, the implementation of this new Firewall could result in **cost-savings of several € millions for Airbus.**

CiTD originally developed the new firewall with the operational necessity to keep costs as low as possible. This design philosophy appealed to Airbus who are exploring ways to reduce costs, and were convinced that a future operational version should be made in the same vein: **"If the existing firewall meets all performance requirements, why not [go for the cheaper materials and approach]?"** – Javier Vazquez, Airbus.

Space-related carbon fibre is very expensive and therefore new approaches that use cheaper materials that pass performance thresholds are of great interest to Airbus. The concept of replacing space-resilient carbon fibre with automotive carbon fibre for firewalls would be beneficial for Airbus, however there is work to be done to certify the concept and qualify this material for aviation. There is a clear trade-off between cost reduction vs. weight (mass) reduction, as cheaper materials tend to increase overall mass (and therefore costs).

**At least 30% total cost saving** as a result of 1 part replacing 30 parts and 100s of fasteners, and accounting for assembly savings.

The cost saving of the new firewall is predominately found in the assembly/installation process (time and labour costs), rather than manufacturing, due to having one single part rather than a number of different pieces (sheet, struts, rivets). The weight of the firewall, whilst being lowered, has a minimal impact on the overall weight of the whole aircraft.

**60% cost savings** in assembly labour hours as a result of a quicker and smoother assembly process.

## Potential for further future benefits from successfully scaling concept to other aircraft parts

The rear firewall was selected for the initial product development and Proof of Concept (PoC) as it was identified as a low-risk part and therefore able to overcome aviation certification challenges (particularly with respect to health and safety standards). The rear firewall is a secondary structure and therefore provides a good case for composites replacing metallics.

With the necessary completion of important tests, certification and flight heritage, the concept could be applied to metallic structures on other areas of the plane, including the rear pressure bulkhead, flat panels, and the fuselage structure. In the future it is possible that several of these individual parts can be woven together.

***Rear Pressure Bulkhead:*** *Scaling the CFRP concept to other structures of the aircraft*

The feasibility study focused on the rear firewall of a single-aisle size Airbus aircraft. However, the new **CFRP concept could potentially be extrapolated to other components responsible of the cabin pressurisation, such as the Rear Pressure Bulkhead, or even to other aircraft families, increasing its commercial possibilities**. In the near term, the design concept could be scaled to replace the current the rear pressure bulkhead—a more significant structure of the aircraft than the firewall and with greater potential benefits, highlighting the extent of this ESA technology transfer.

### *Flight capacity*

Whilst the implementation of a new rear firewall will have a relatively immaterial impact on aircraft capacity, it is possible that extending the concept to the rear pressure bulkhead could lead to improvements in terms of mass saving, volume, and part integration, that may create space for an additional seat row or cargo if the solution can be successfully scaled. This would present a significant commercial benefit for Airbus.

### *Supporting the new generation of climate-friendly planes*

Airbus is designing its future generation of aircraft, including hydrogen powered aircraft. The new CFRP firewall and successful scaling of the concept to other aircraft structures, applied to these new aeroplanes, would result in the ESA technology transfer playing a role in the new Clean Aviation European program.

## Would these benefits have been realised without ESA?

CiTD worked with ESA's Technology Transfer Patent Office (TTPO), who stimulate new business lines, increase return on investment, and commercialise space applications for Earth. Starting with an initial feasibility study, the project advanced to a Proof-of-Concept (PoC) stage which culminated in the prototype firewall being successfully tested at Airbus, incorporating critical fuselage interfaces.

**ESA's support and backing has been critical throughout the whole process for CiTD and Airbus.** ESA's validation of the concept and ability to show its significance, provided CiTD with the necessary confidence to go ahead and develop the new firewall. ESA have helped show how you can sometimes do more with less and this case study provides a great example of space industry technology transfer to terrestrial sectors. ESA's technical expertise in structural engineering was very beneficial for CiTD and Airbus. For CiTD, having a physical component to show Airbus was game-changing for convincing them to explore adopting the new part.

**"We pushed and pushed then finally, through ESA's involvement, we got our chance to try."**

*Marta García Cosío, CiTD*

## … and more to come as technology development continues

Having completed the feasibility study to evaluate potential performance and with the successful development of an initial stage proof of concept, Airbus is now testing the firewall on the A320 NEO aircraft where the firewall is currently at TRL 6. Mechanical testing on a full-scale firewall, as well as overpressure and fire testing needs to be completed, with the expectation that demonstrator testing with aviation material will move the TRL to 8. The tests will determine whether constructing the firewall from automotive-grade composite material rather than the more costly aeronautic-grade material is sufficiently resilient to be qualified for aviation purposes.

A second stage PoC will consist of a structural demonstration, whilst the third and final PoC will trial a new manufacturing process. The demonstrator will be completed with the final material selected alongside Airbus for next aircraft developments and in line with the updated classification of secondary structures. Future demonstrators will assess scaling up the manufacturing process to 40-50 parts per month, where automation will play an important role.