Shrinking the carbon footprint and improving the bottom line

Close to 5 million tons of kerosene per year. That’s the fuel savings the global fleet of aircraft could achieve with AeroSHARK coating technology. And we’re well past proof of concept.

Improving fuel efficiency - and the other directly related key benefit: lower emissions - starts with anything that helps the aircraft cut through the air with the least drag and the most lift - in addition to less weight, of course. Just like a shark cuts through the water.

Nature makes it look so easy
It's not just a streamlined body, optimal fin configuration and quite a few pounds of pure muscle that make sharks the most energy-efficient swimmers in the history of the planet.

What 450 million years of evolution also gave the shark is great skin. It consists almost entirely of small placoid scales that shift independently to reduce friction. They increase buoyancy while generating low-profile vortices that reduce hydrodynamic drag and even add a thrust component. The faster the shark moves through the water, the more efficiently it does so.

Theory shows that replicating this skin structure on the fuselage of an aircraft can reduce friction by more than 2%. Extrapolated to the global fleet of aircraft, this translates into just under 5 million metric tons of fuel that could be saved each year.

Biomimetics meets aeronautics and chemical engineering
In partnership with BASF, the world's leading chemical and coatings manufacturer, Lufthansa Technik has developed a functional biomimetic technology: a film with a barely perceptible ribbed texture made up of small elevations – so-called riblets. The film has millions of these prism-shaped riblets, each 50 micrometers high, making it easy to apply in a targeted way. The film is selectively applied to the aircraft body depending on the type and function of the surface - wings, fuselage or control surfaces. When aligned with the airflow, the riblets achieve efficiency gains, i.e. reduced friction and improved lift, similar to their counterparts in nature, the denticles on sharkskin.

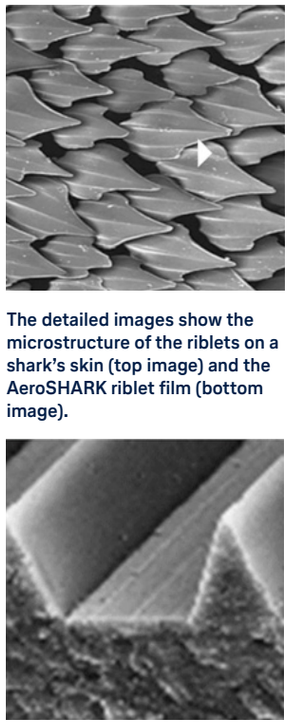
LIKE A SHARK CUTTING THROUGH WATER

More than a cost-effective and scalable solution
Combining BASF's advances in coating technologies and application processes with data gathered through Lufthansa Technik's extensive experience, research and testing resulted in a winning solution, one that is unique because it checks all the key boxes: cost-effectiveness, scalability, retrofittability and sustainability. And the latter not only because of its impact on fuel savings and emissions reduction, but also its lower manufacturing and application footprint compared to other technologies.

Leveraging the certification advantage
After an extensive evaluation phase to validate the initial test results, Lufthansa Technik gave the go-ahead for a series of application tests on a decommissioned aircraft in August 2019. By October, the team was up to speed and expertly applied 500 square meters of riblet film to the lower fuselage of a Boeing 747-400 from the Lufthansa fleet. In early November 2019, the European Union Aviation Safety Agency (EASA) granted the Supplemental Type Certificate (STC) required for flight trials and the first AeroSHARK jumbo jet reported for active service. The key to fast-tracking the project to test flights in record time was Lufthansa Technik's EASA Part 21 certification as an aircraft design organization. This ensured compliance for the entire scope of work, from specifying the materials for the riblet film to stipulating the application method.

Just as importantly, it allowed BASF to focus its resources on the riblets, the film and its properties.

No hype. Results.
By late November 2019, it was clear that the riblet film, developed jointly with BASF's Coatings division, was delivering what it promised under real-world operating conditions. The AVIATAR Fuel Analytics solution developed by Lufthansa Technik was used to measure variations in fuel consumption before and after the modification to within 0.1%, accurately factoring in external factors such as weather conditions, the flight profile and even minor impacts on the fuselage. Initial results for the Boeing 747- 400 with a lower fuselage modification showed a friction reduction of 0.8% due to the effect of AeroSHARK, equivalent to an annual fuel saving of approximately 300 metric tons of kerosene. This corresponds to a reduction in C02 emissions of more than 900 metric tons per year.



The detailed images show the microstructure of the riblets on a shark's skin (top image) and the AeroSHARK riblet film (bottom image).

And cost savings of approximately 225,000 euros, including 25,000 euros saved by avoiding the purchase of emission certificates. And that's just for one aircraft

Ready to tap the full potential of riblet film technology
Lufthansa Technik is always committed to providing real added value to its airline customers and continues to develop innovative and viable solutions to reduce the impact of aviation on the environment.
This first trial of riblet film on one of our proven Boeing 747-400s is just the first successful milestone. We have already shifted into a higher gear to accelerate the certification of a riblet film package for wings and control surfaces as well.

This will increase the total friction reduction from the current 0.8% (lower fuselage) to 2.5% on the aircraft's outer skin, effectively tripling the benefits. Development for other Boeing and Airbus aircraft types is currently underway.

The AeroSHARK effect

0.8% friction reduction confirmation on Boeing 747-400 p.a.

approx. 300t
fuel savings

>900t
emission reduction

>€200,000
cost savings

0.8 to 2.5% friction reduction

180 g / m²
weight

4+ years
durability

<2 years
ROI

Estimated fuel burn reduction for global fleet at 1% friction reduction p.a.

2 m. t
fuel savings

6.3 m. t
emission reduction

approx. €1 bn
cost savings

3 QUESTIONS TO ...

Jens-Uwe Müller, AeroSHARK project leader at Lufthansa Technik's main base at Hamburg Airport.

1

Why a Boeing 747-400 for the real-world validation tests? Wouldn't a newer aircraft have greater potential for fuel savings and lower emissions?

The main reason for selecting the Boeing 747-400 is that it is the perfect platform to demonstrate that significant savings are possible with tried and tested aircraft, so airline customers can see the benefits of retrofitting aircraft already in service. We also have decades of experience with this type, which was crucial to accelerating the testing and certification process. The fact is that our riblet technology can be applied to any aircraft. We are already conducting further validation on other types and discovering that the savings are all in a similar range.

> The fact is that our riblet technology can be applied to any aircraft with a similar effect.

2

The tests have proven the effectiveness of the riblet film. What are the rollout plans?

The riblet film technology was supposed to be rolled out to the rest of Lufthansa's Boeing 747-400 fleet (13 aircraft) in March 2020, but unfortunately, COVID-19 made major rescheduling necessary in the Group's aircraft planning. For the time being, installation of the riblet film on the Boeing 747-400 is limited to the lower half of the fuselage.

For one thing, the certification requirements for modifying this section were less complex. More importantly, however, this area is subject to higher stresses from dirt and liquids. If the riblet film survives there, it will survive anywhere. The wing and tail units remain a primary target because of their large surface areas and the resulting potential for fuel savings.

We were delighted to acquire Lufthansa Cargo as our next customer and look forward to making this innovative technology available to more and more airlines as quickly as possible. To realize the greatest possible savings potential with the greatest possible market penetration, we are now looking for more airlines to participate in the success of the AeroSHARK effect.

3

How do you measure fuel savings before and after the modification? Does a 1% change even move the needle?

A multitude of factors can skew the result. We use AVIATAR Fuel Analytics for accurate before and after comparisons. Using real-world consumption data from the flow rate sensors on all four engines of the test Boeing 747-400, the software algorithm can filter out various potentially distorting factors. Starting from a savings potential as low as 0.5%, AVIATAR delivers precise measurements to within +/– 0.1%, so that the effect of AeroSHARK is clearly visible.