PROJECT

SADE

Smart High Lift Devices for Next Generation Wings

**Funding:** European (7th RTD Framework Programme)

**Duration:** May 2008 - Oct 2012

**Status:** Complete with results

**Total project cost:** €7,093,862

**EU contribution:** €4,969,975

Call for proposal: FP7-AAT-2007-RTD-1

CORDIS RCN: 89908

Background & policy context:

SADE aimed at a major step forward in the development and evaluation of the potential of morphing airframe technologies and contributed to the research work calling for the reduction of carbon dioxide and nitrogen oxide emissions through new intelligent low-weight structures. All aerodynamic concepts for significant reduction of drag, such as laminarisation require slim high-aspect-ratio wings. However, State-of-the-Art high lift systems will suffer from the reduced construction space and will not cope with the required surface quality. Therefore, SADE developed suitable 'morphing' high lift devices: The seamless 'smart leading edge device' is an indispensable enabler for laminar wings and offers a great benefit for reduction of acoustic emissions. The 'smart single slotted flap' with active camber capability will permit further increased lift. Thanks to their ability to adapt the wing's shape, both devices also offer aerodynamic benefits for cruise flight.

Morphing devices imply the integration of drive systems into tailored lightweight structures and therefore, reduce complexity and mass. Furthermore, focussing on electric actuators the energy consumption can be reduced, which directly reduces the aircraft operational costs, as well as the environmental impact. However, the high elasticity required for efficient adaptability of the morphing structure is diametrically opposed to the structural targets of conventional wing design, such as stiffness and strength. To find the optimum compromise, precise knowledge on target shapes for maximum high lift performance and sizing loads is mandatory. Therefore, SADE comprised all relevant disciplines for the investigation of morphing wings and operated a State-of-the-Art virtual development platform. Nevertheless, SADE focused on the structural challenge of realising morphing high lift devices.

SADE has built on available promising concepts for smart structures. The technological realisation and optimisation of these concepts towards the special requirements of full scale systems is the most essential challenge for morphing today. Another challenge results from the aeroelastic condition the structural system has been optimised for. Therefore, a realistic full scale section of a morphing wing was to be manufactured and tested in the TsAGI T101 wind tunnel for an investigation of these effects.

Objectives:

Develop and investigate the morphing high lift devices 'smart leading edge' and 'smart single slotted flap'.

- Enhance morphing structure concepts and develop solutions which cope with requirements of real aircraft and of industrialisation;
- Increase technological readiness of morphing structures and experimentally verify this;
- Perform multidisciplinary designs and assess benefits for the overall system and for all individual disciplines;
- Reduce system complexity and mass;
- Enable seamless high lift devices and therefore, enable laminar wings;
- Increase lift-over-drag in take-off and therefore, enable steeper climb and reduce noise footprint;
- Increase maximum lift in approach referring to conventional droop nose devices;
- Reduce noise emissions in approach compared to high lift systems containing slats;
- Reduce power consumption following the more-electric-aircraft concept;
- Concentrate European experts in morphing and create a road map until the first experimental flight with morphing wing devices is in full scale.

**Methodology:**

Work Package 1 - Integration
Work on the entire wing to obtain the base design and requirements for the development of smart high lift devices. Furthermore, application independent smart structure concepts, such as highly anisotropic composite materials have been investigated in this WP and form the technical basis for WP2 and WP3, together with the joint background knowledge. The integration of the smart high lift devices into aircraft configurations and the following simulations are evaluation activities within the second half of the project.

Work Package 2 - Smart Leading Edge
Elementary morphing concepts tailored to the SLE have been developed, combined and enhanced. The most promising solution was designed in detail and optimised. The work was numerical and considered the boundary conditions of a real aircraft configured with SLE and conventional fowler flap. Evaluation of WT experiments concerning SLE were allocated in this WP.

Work Package 3 - Smart Single Slotted Flap
This was the equivalent for WP2, investigating and optimising the SSSF device in combination with a conventional droop nose. Evaluation of structural experiments concerning SSSF was allocated in this WP.

Work Package 4 - Wind Tunnel Experiment
The wind tunnel model was designed for the specific boundary conditions of the experiment. Design, manufacture, test and pre-processed test results were allocated in this WP.

**Parent Programmes:**

*FP7-TRANSPORT - Transport (Including Aeronautics) - Horizontal activities for implementation of the transport programme (TPT)*

**Institute type:** Public institution  
**Institute name:** The European Commission  
**Funding type:** Public (EU)  
**Other programmes:** Programme acronym or name (optional)  
**Other countries:** Other countries (optional)  
**Other funding sources:** Information about the funding institution (optional)

**Lead Organisation:**

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**EU Contribution:** €1,048,904

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<th>Organisation Name</th>
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Technologies:

Aircraft design and manufacturing
Morphing wing

Development phase: Research/Invention

Key Results:

Selection was carried out for further activities regarding SLE (Smart Leading Edge) and SSSF (Smart Single Slotted Flap). For the SLE the kinematic chain in combination with the flexible skin would be pursued further. This concept would be tested in a wind tunnel experiment in full scale at the end of the project. Among the SSSF concepts, the selection process resulted in a further pursuit of the horn concept, as well as of the SDS based cellular substructures, both in the form of complementary studies.

The first and most obvious result from the Wing Tunnel Experiment is that no structural damages of the highly stressed skins were detected, even after several hours of testing and several cycles of deforming the nose. This is proof that even morphing primary structures can be designed and built for highly loaded components, such as aircraft wings for transport aircraft. The evaluation of the optical deformation measurement showed low overall deformations (1.4 mm) caused by the aerodynamic loads. The same deflections were found for clean and landing conditions. This indicates that the loading in the skins is dominated by the strain through morphing and that the aerodynamic loads cause small deformations compared to that when correctly designed. Detailed evaluation of the pressure distribution and the deformations on the sensitive upper (suction) side of the leading edge revealed that even tiny variations in the distribution of curvature, due to manufacturing, induce a remarkable effect on the achievable maximum lift.

Innovation aspects

Designing and developing the morphing high lift devices 'smart leading edge' and 'smart single slotted flap'. In doing so there was a special emphasis on enhancing morphing structure concepts and developing solutions which cope with the requirements of real aircraft and of industrialisation.

Technical Implications

- Designing and developing new concepts of SLE and SSSF;
- Integrating the new concepts into real aircraft wings and testing them in a wind tunnel.

Strategy targets

The morphic Smart High Lift Devices successfully integrated into aircraft wings could potentially lead to fuel and energy efficiency. Moreover, the project is innovating for the future which is in conformity with the European Transport Research and Innovation Policy.

Readiness

Further research is necessary - The technological realisation and optimisation of these concepts towards the special requirements of full scale systems is the most essential challenge for morphing today and needs further research input in order to be successfully implemented.

Documents:
- [SADE Newsletter 2009 (Other project deliverable)]

STRIA Roadmaps: Vehicle design and manufacturing

Transport mode: Air transport

Transport sectors: Passenger transport, Freight transport

Geo-spatial type: Other