

SADE

NEWS



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Collaborative Level 1 Project

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Preface

The first project year of SADE is over and after a successful start all 13 partners have been working hard to reach the challenging research objectives. Some selected results will be described consecutively.

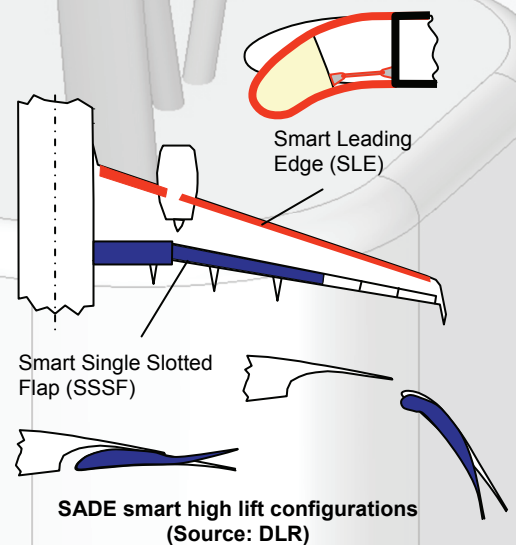
Dissemination activities have started and resulted in a first version of the SADE internet homepage and, as can be seen, in this newsletter.

The aim of this newsletter is to give a brief overview of the recent and planned activities in SADE on a regular basis and to encourage anyone interested to get in contact with partners from the consortia.

Introduction to SADE

SADE aims at a major step forward in the development and evaluation of the potential of morphing airframe technologies. The project contributes to the research work called for the reduction of carbon dioxide and nitrogen oxides emissions through new intelligent low-weight structures. Research for 'smart' structures and morphing airframe will open new horizons in aircraft lightweight design.

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 do not cope with the required surface quality. Thus, SADE develops 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 permits a further increased lift. Thanks to their ability to adapt the wing's shape, both devices also offer aerodynamic benefits for cruise flight.



Contact



Dr. Hans Peter Monner
Deutsches Zentrum
für Luft- und
Raumfahrt e.V. (DLR)
Institute of Composite
Structures and Adaptive Systems
Lilienthalplatz 7
D-38108 Braunschweig

Phone: +49 531 295 2314
Fax: +49 531 295 2876
E-Mail: hans.monner@dlr.de

SADE builds 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 is optimised for. Hence, a realistic full scale section of a morphing wing will be manufactured and tested in the TsAGI T101 wind tunnel for an investigation of these effects.

The project is subdivided into four research related work packages (WP):

WP1 'Integration': Work on the whole wing to obtain the basis design and requirements for the development of smart high lift devices. Furthermore application independent smart structures concepts like highly anisotropic composite materials are 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 following simulations are evaluation activities in the second half of the project.

WP2 'Smart Leading Edge': Elementary morphing concepts tailored for the SLE are developed, combined and enhanced. The most promising solution will be designed in detail and be optimised. The work is numerical and considers the boundary conditions of a real aircraft configured with SLE and conventional fowler flap. Evaluation of WT experiments concerning SLE is allocated in this WP.

WP3 'Smart Single Slotted Flap': This is the equivalent for WP2 investigating and optimising the SSSF device in combination with a conventional droop nose. Evaluation of structural experiments concerning SSSF is allocated in this WP.

WP4 'Wind Tunnel Experiment': The wind tunnel model will be designed for the specific boundary conditions of the experiment. Design, manufacture, test and pre-processed test results are allocated in this WP.

SADE Homepage

The external Homepage can be found under <http://www.smr.ch/sade/>. A concept for its composition and maintenance has been developed. It features two levels of information: an entry page and several secondary level pages. The entry page consists of a short description of project and interesting pictures. The second level will consist of the following topics: 'About', 'Contact' and 'Newsletter'. New newsletters will be generated once a year, featuring recent results. The goal is to keep the homepage simple in order to keep maintenance requirements of the homepage small without sacrificing relevant information.

Selected Results

After gathering the reference data aerodynamic target shapes for the deformed SLE and SSSF have been calculated. In parallel aeroservoelastic effects of the wing considering an attached SLE were investigated. Meanwhile the design of the wind tunnel model has reached quite a sufficient level of maturity. However, the

main focus of the first year was placed on proposal and evaluation of different structural concepts for the 'Smart Leading Edge' (SLE) and the 'Smart Single Slotted Flap' (SSSF). Following a brief summary of some selected results and achievements are presented.

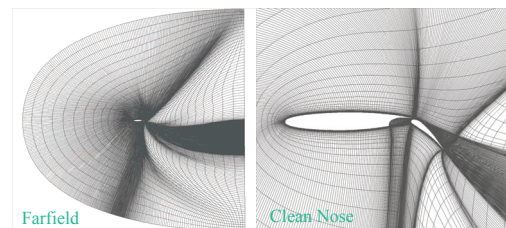
Reference Data

As a geometric baseline, both FNG and HARLS data were selected. With the permission from the EU FP6 project co-ordinator of NACRE SADE is allowed to use variants of the HARLS wing. The data about this geometry is now available to all SADE partners as a common basis. At the same time FNG data was provided by those partners that were previously involved in its development.

Another input for the reference data are the industrial requirement, which were collected by the industrial partners and made available to the SADE partners.

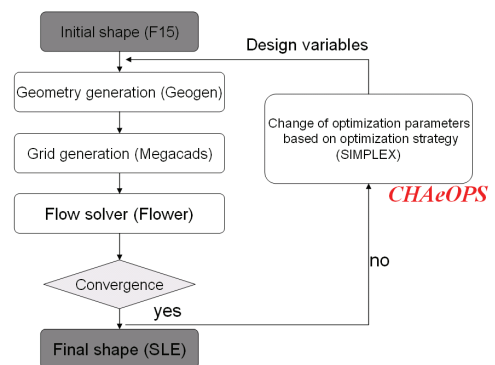
Target Shapes

The flight physics of a leading edge with and without droop nose is being investigated in a 2D CFD. The structured grid generator MegaCADs is used to derive a parametric grid setup which allows deformation of mesh during optimization (clean nose to droop nose). A convergence check was also successfully performed. General size of the grid is 65,200 nodes in 16 blocks.



2D CFD mesh of clean droop nose (Source: DLR)

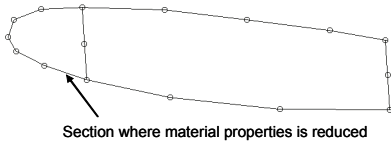
The overall strategy of the optimization process is already established but the integration of the droop nose curve length into the optimization is still under progress. But it is agreed that the optimization tool CHAeOPS will be used to perform the subsequent steps. It is also suggested to use a SIMPLEX algorithm during the optimization due to its stability and good performance for high lift, low speed case.



Optimization chain for target shapes (Source: DLR)

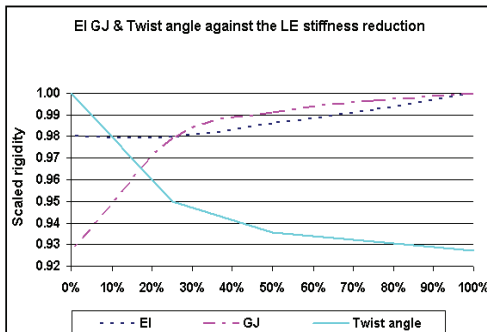
Aeroservoelastic Effects

In order to estimate how the stiffness reduction of a SLE reduces the overall stiffness of the wing in comparison to a fixed nose a set of aeroservoelastic investigations were performed. Firstly a thin-walled composite wing box model to calculate the stiffness with consideration of the warping effect was established. Based on the available scaled FNG wing box model, the effect of warping and stiffness on the deformation (twist) of the 3D model was calculated by varying the elastic constant E and rigidity constant G of the LE bottom skin section from 100% to 0% (open LE reduces to a one-cell box). The effect of stiffness reduction on the overall wing box LE torsional and bending rigidity was assessed. Secondly the LE deformed shape and the resulting aerodynamic lifting coefficient (2D) was evaluated.



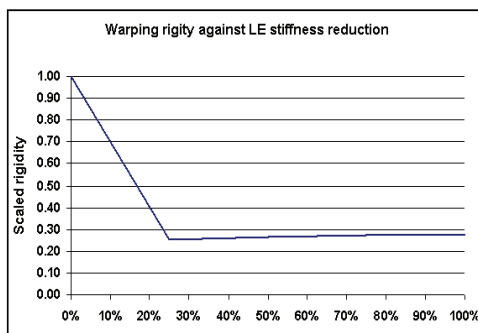
Thin-walled boxed modell (Source: Cranfield University)

The results show that the LE bottom section E and G can be reduced by 50%, without significantly compromising the torsional and bending rigidity of the whole wing box. If the LE bottom section E and G are reduced by 75% and below, the rate of reduction in torsional rigidity is greater and this leads to an increase in twist angle up to 10% for a wing box length $L=0.5m$.



Torsional rigidity (Source: Cranfield University)

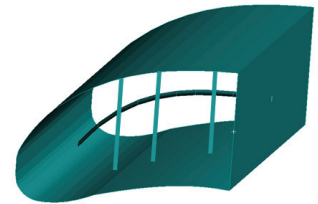
Furthermore the warping stiffness increases significantly, when the LE bottom sections E and G are reduced by 75% and below.



Warping stiffness (Source: Cranfield University)

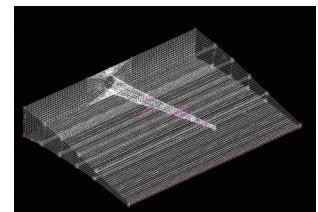
Eccentric Beam

For the SLE the eccentric beam actuation mechanism is connected to a set of disks, which are contacted to some of the stringers of the leading edge skin. When the beam is rotated by an actuator, the disks push the LE skin structure downwards. The beam can be manufactured in a curvature to match with the specified deflected LE shape at any rotating angle.



Eccentric beam concept for SLE (Source: Cranfield University)

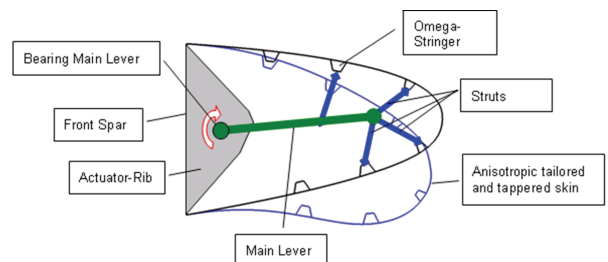
The similar approach was proposed for the SSSF and is named the horn concept. The eccentuator consists of a bent beam that converts a rotary input motion into a vertical and lateral translation at the output end. This output end rides on a bearing surface which is forced to move upwards or downwards depending on the direction of the rotation of the beam. With a pair of eccentuator it is possible to achieve precise control of structural bending and twisting.



Eccentric beam concept for SSSF (Source: Cranfield University)

Kinematic Chain

Another proposed concept to realize a smart leading edge is based on a kinematic chain in combination with an elastic skin. Such a kinematic would introduce the displacements at several points into the flexible skin. Other concepts concentrate on solid skin made from already certified composite materials, where the morphing capability is realized via skin bending and without elongation/compression of the skin. To keep the tensions within the limits, the skin thickness has to be minimized in areas of high deformations. As actuators electromechanical or hydraulic devices are feasible.

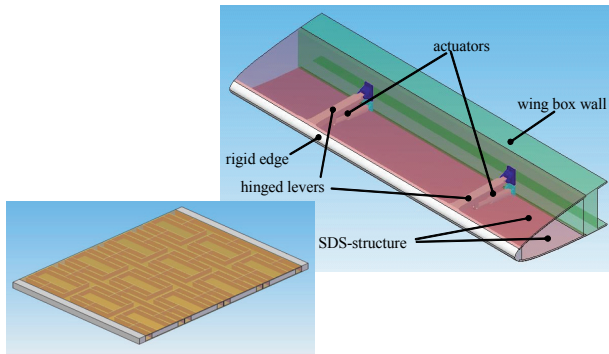


Kinematics for skin deformation (Source: EADS & DLR)

Selective Deformable Structure (SDS)

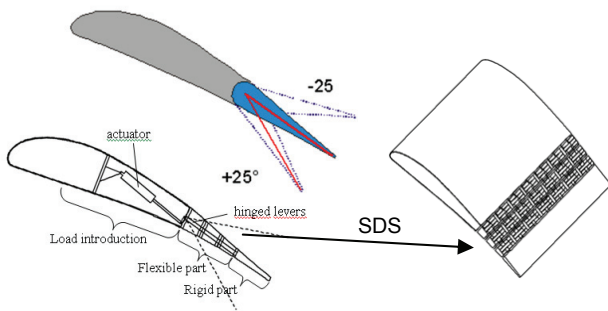
With respect to the SLE a concept based on so-called selective deformable structures (SDS) was suggested. Due to its specific design SDS allows large deformations in one desired direction and provides sufficient stiffness in the other directions. SDS requires elastic filler in order

to provide the required aerodynamic contour. As skin material substitute in combination with appropriate actuators (e.g. electromechanic devices) and hinged levers a SLE can be realised.



SLE SDS concept (Source: TsAGI)

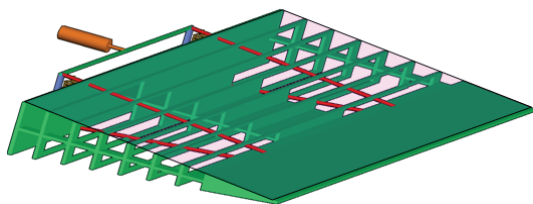
Also there was the proposal of a SDS based concept for the SSSF. It consist of rigid parts in the span-wise element, which are attached to the SSSF inside the skin by means of some hinged levers. The flexible SDS-structure is a SDS-panel attached to the rigid edge and SSSF skin. This panel is formed like an external profile and takes the aerodynamic loads. As by the SLE actuators can be electromechanic devices.



SSSF SDS concept (Source: TsAGI)

Pre-Stressed Steel Cables

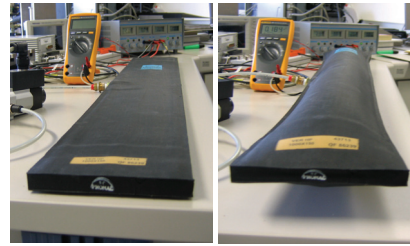
Another concept is the flexible trailing edge with activation via pre-stressed steel cables. The concept aims at producing curvature variations of the aft part of a movable flap. The architecture is constituted by an internal aluminium alloy flexible beam/plate structure (green component), supplied with stiffeners suitably connected to steel cables (red components), moved on the root by a servo-actuator (orange component).



SLE based on pre-stressed cables (Source: CIRA)

Fluidic Actuator Concept

This SLE actuation concept uses flat tube actuators. The aim is a highly integrated approach for an adaptive structure-system. The according concept comprises inflatable adaptive structural actuators providing active means together with structural tasks. The shape adaptability can be either by pressure controlled (elastic wall structure) or volume controlled (flexible but non-elastic wall structure) operation.

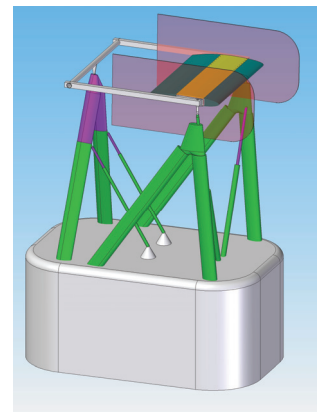


Fluidic actuators (Source: EADS)

Possibly there need to be multiple independent chambers; each may be controlled by a separate control loop, maybe in a hierarchical architecture.

Wind Tunnel Experiment

In preparation of the scheduled wind tunnel experiment the planning has also started. The model size and general geometry was decided on. Structural limitations of the test setup were also considered as well as aerodynamic boundaries. The model will be 5 m wide and 3 m in chord direction. The design for the test setup is already in progress, so that the smart leading edge model can be tested in the wind tunnel in 2011.



Set-up for wind tunnel experiment (Source: TsAGI)

Concept Selection

Based on these proposed concepts a selection was carried out for further activities regarding SLE and SSSF. For the SLE the kinematic chain in combination with the flexible skin will be pursued further. This concept will be tested in a wind tunnel experiment in full scale at the end of the project. Besides that the eccentric beam actuation mechanism was selected for complementary studies as well as the fluidic actuators and the combination of SDS structures and monolithic skins. In the course of this project the structural design of these concepts will be worked out.

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 form of complementary studies. After a design phase demonstrators will be built for these concepts within this project. ■