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PROJECT FINAL REPORT

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Project acronym: SADE

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4.1 Final publishable summary report

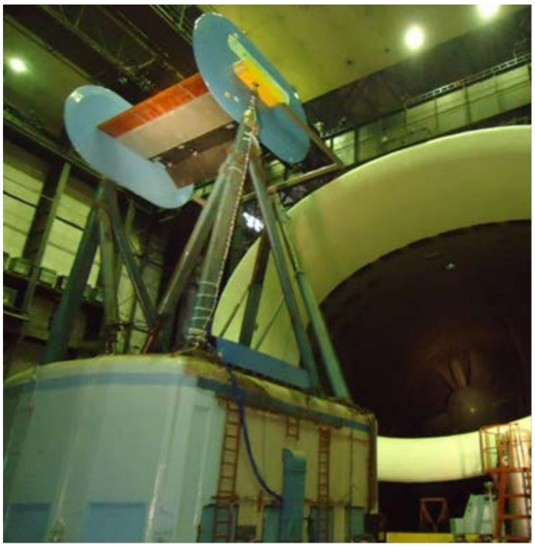
An executive summary (not exceeding 1 page).

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.

Several concepts for droop nose and trailing edge morphing were proposed, developed and evaluated during the course of the project. The gapless stepless droop nose concept with kinematic chain and elastic skin, that can droop the nose by 18°, was chosen to be tested in a wind tunnel experiment.

The wind tunnel model is a rectangular wing of 5 m span and 3 m chord with constant profile and no taper. A test matrix of various wind speeds between 30 and 50 m/sec is run, varying the angle of attack between -10° and +22°. Three configurations are distinguished: take off (nose drooped, trailing edge flaps in take-off position), cruise (nose clean, trailing edge flaps retracted) and landing (nose drooped, trailing edge flaps in landing position. The model is equipped with strain gauges to measure the strain, pressure tubes and an optical measurement technique to measure the deflections of the droop nose under aerodynamic loading.



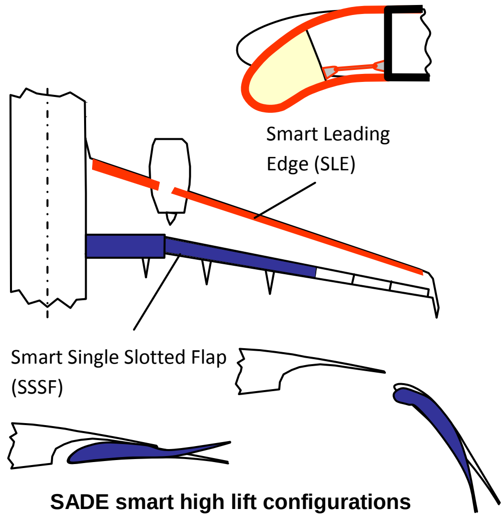
The campaign is carried out in TsAGIS very large WT-101 near Moscow, with an elliptic nozzle that measures 14 x 24 m. The goal of this campaign is a structural prove, that the morphing GFRP skin in capable to be changed in contour significantly, but still caries all aerodynamic loads – this is why a full scale model was required. On the other hand, the CFD predictions for the morphed airfoil were to be proven. The very successful outcome of this test 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. The comparison with 3D CDF showed especially for lower angles of attack up to 10° a very good accordance with the experimental data.

It can be concluded, that SADE stands for a major step forward in the development and evaluation of the potential of morphing airframe technologies in the high lift area. The wind tunnel experiment can be considered a milestone for morphing technologies and showed that large deformations are possible even for load carrying structures in full scale. The next step has to be the prove, that demands from operation requirements such as bird strike etc. can be incorporated into such morphing leading edges as well. Finally SADE helped to build up and mature a vast amount of additional concepts for droop nose and trailing edge morphing, which might be eventually alternatives to the concept chosen for the wind tunnel experiment. Also tools are available now, that can evaluate the benefit of such systems on an overall aircraft design.

A summary description of project context and objectives

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.



SADE smart high lift configurations (Source: DLR)

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.

A description of the main S&T results/foregrounds

Selected Results of 1st year

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.

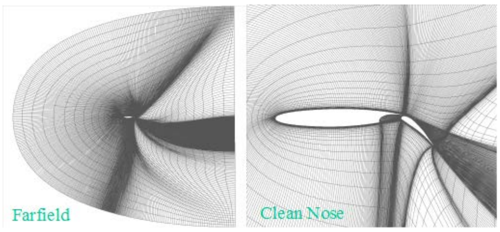
Reference Data

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.

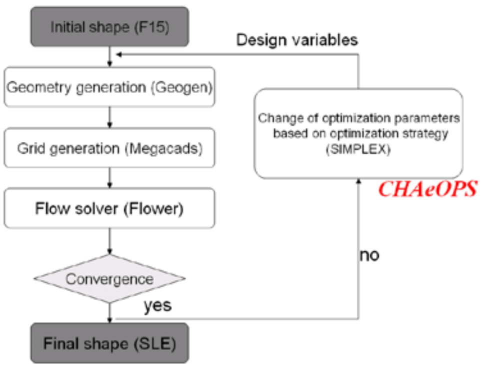
Target Shapes

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)

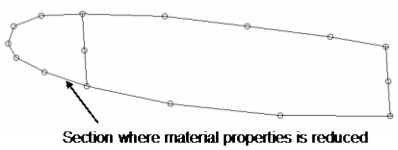
The overall strategy of the optimization process is already established but the integration of the droop nose curve length into the optimization is still under progress. But it is agreed that the optimization tool CHAeOPS will be used to perform the subsequent steps. It is also suggested to use a SIMPLEX 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

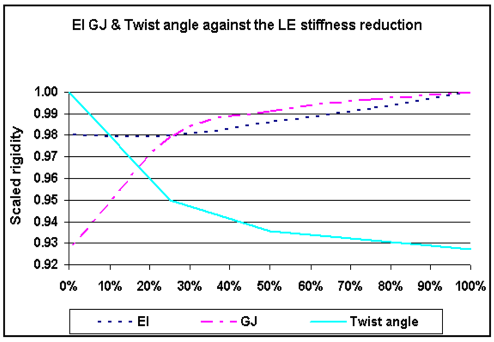
In order to estimate how the stiffness reduction of a SLE reduces the overall stiffness of the wing in comparison to a fixed nose a set of aeroservoelastic investigations were performed. Firstly a thin-walled composite wing box model to calculate the stiffness with consideration of the warping effect was established. Based on the available scaled FNG wing box model, the effect of



Thin-walled boxed modell (Source: Cranfield University)

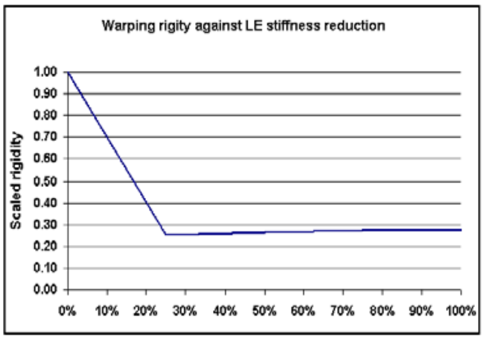
warping and stiffness on the deformation (twist) of the 3D model was calculated by varying the elastic constant E and rigidity constant G of the LE bottom skin section from 100% to 0% (open LE reduces to a one-cell box). The effect of stiffness reduction on the overall wing box LE torsional and bending rigidity was assessed. Secondly the LE deformed shape and the resulting aerodynamic lifting coefficient (2D) was evaluated.

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.



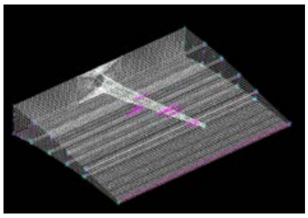
Warping stiffness (Source: Cranfield University)

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)

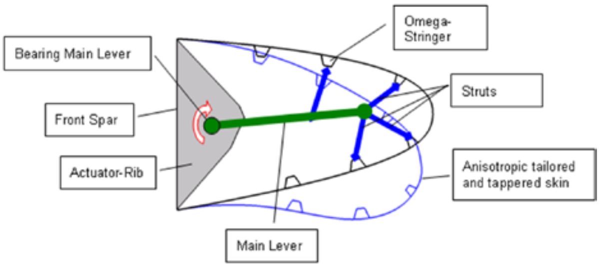
The similar approach was proposed for the SSSF and is named the horn concept. The eccentuator consists of a bent beam that converts a rotary input motion into a vertical and lateral translation at the output end. This output end rides on a bearing surface which is forced to move upwards or downwards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



Eccentric beam concept for SSSF (Source: Cranfield University)

Kinematic Chain

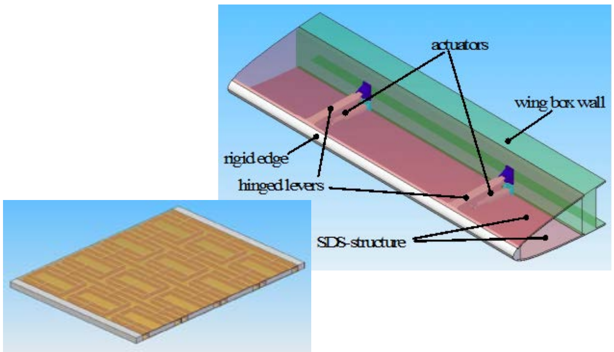
Another proposed concept to realize a smart leading edge is based on a kinematic chain in combination with an elastic skin. Such a kinematic would introduce the displacements at several points into the flexible skin. Other concepts concentrate on solid skin made from already certified composite materials, 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.



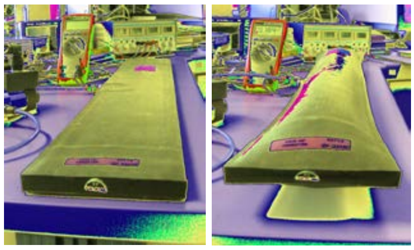
Kinematics for skin deformation (Source: EADS & DLR)

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.

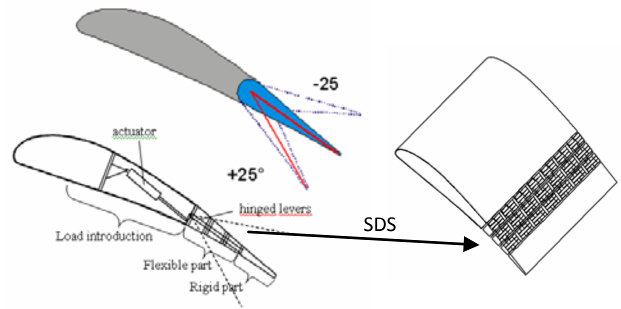


SLE SDS concept (Source: TsAGI)



Fluidic actuators (Source: EADS)

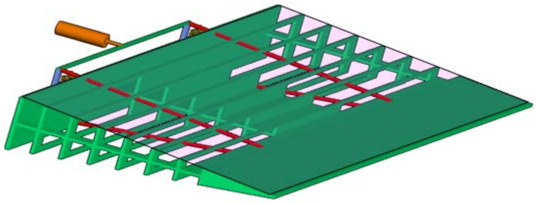
Also there was the proposal of a SDS based concept for the SSSF. It consist of rigid parts in the span-wise element, which are attached to the SSSF inside the skin by means of some hinged levers. The flexible SDS-structure is a SDS-panel attached to the rigid edge and SSSF skin. This panel is formed 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. Possibly there need to be multiple independent chambers; each may be controlled by a separate control loop, maybe in a hierarchical architecture.

Concept Selection

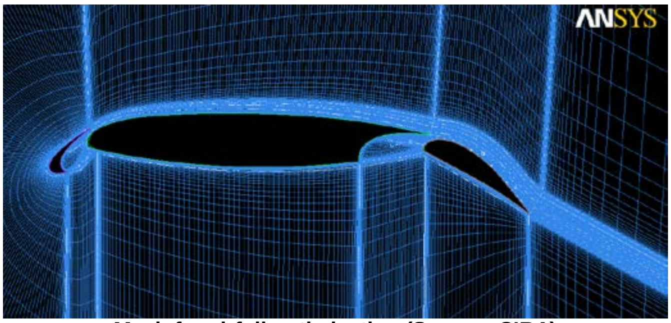
Based on these proposed concepts a selection was carried out for further activities regarding SLE and SSSF. For the SLE the kinematic chain in combination with the flexible skin will be pursued further. This concept will be tested in a wind tunnel experiment in full scale at the end of the project. Besides 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.

Selected Results of 2nd year

Airfoil Optimisation

In order to understand the impact of rear part flap deformation on high lift performances a preliminary optimization has been performed. The analyses were performed using the Euler-boundary-layer method MSES. The 2D mesh is a structured one with 45 blocks and 98288 quadrilateral cells.

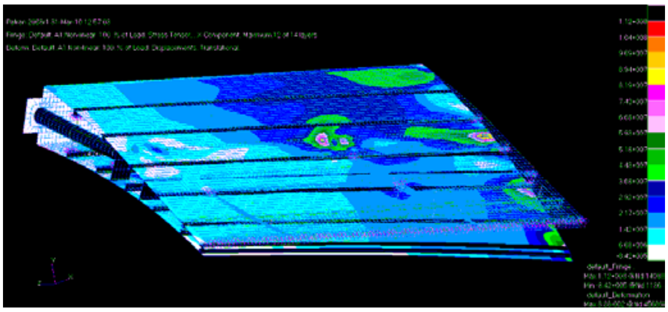


Mesh for airfoil optimisation (Source: CIRA)

Geometrical constraints for the optimization were the gap and overlap ranges. The allowed flap trailing edge deformation is limited to 12.5% of the clean wing chord size. The calculations were carried out for Mach number 0.15 and Reynolds number 7·106. The design variables for the optimization were flap deformation, flap and slat position and rotation as well as angle of attack. The optimization with a genetic algorithm using 500 generations and 20 individuals leads to a significant improvement of cL from 3.5 to 3.9. A more detailed optimisation using the ZEN RANS SOLVER is being prepared.

Horn Concept

The horn concept is meant to change the contour of a trailing edge by means of “hornlike” shaped eccentuators which are converting rotary input motion into vertical displacements at the skin. Depending on the shape of the eccentuator the trailing edge shape can be adjusted. A detailed design study for this concept has been carried out to investigate the stress and strain state of such a trailing edge under aerodynamic and actuation loads. Both, aluminium and glass fiber reinforced plastic (GFRP) were considered as skin material. The highest stress values (< 460 MPa) were observed on the curved beam in a region close to the rear spar. The maximum stress (233 MPa for Al and 98 MPa GFRP) value in chordwise direction within the skin is at the contact of the eccentuator with the skin. This leads to strains below the allowable of 0.4% for both GFRP and Aluminium.

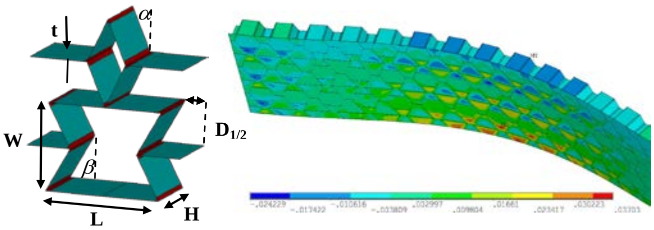


Stress distribution of trailing edge with horn concept
(Source: CU)

Further studies considering extending to the full scale SADE flap TE will consider GFPR skins, only. The investigation of the dynamic response of the TE flap including nonlinear effects for low speed conditions is in progress.

Cellular Substructure

With respect to the SSSF a patented substructure is investigated, which would support the skin of a morphing flap. This substructure is a cellular structure with zero poison ratio, which would be beneficial for morphing of large spans of wings or flaps.

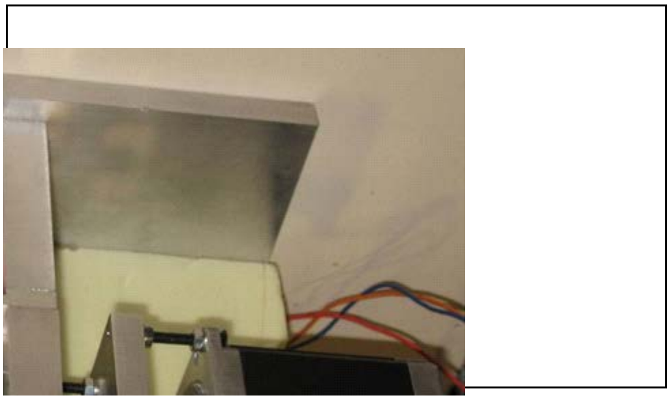


Left: unit cell of a substructure with zero poison ratio,
Right: skin buckling when bending (Source: DLR)

A detailed analysis of this structure shows the critical sensitivity of the design regarding the hinges. It was found, that bending and the addition of filler or skin material has an influence on the poison ratio and can lead to buckling within the skin. This has to be taken into account when designing structures with this type of material.

Compliant Mechanism

During the concept study several approaches of how to realize a droop nose were investigated. One of these studies is shown in the figure below. A scaled model of a leading edge with aluminium skin was designed and tested to deform using an electric motor and a compliant mechanism.

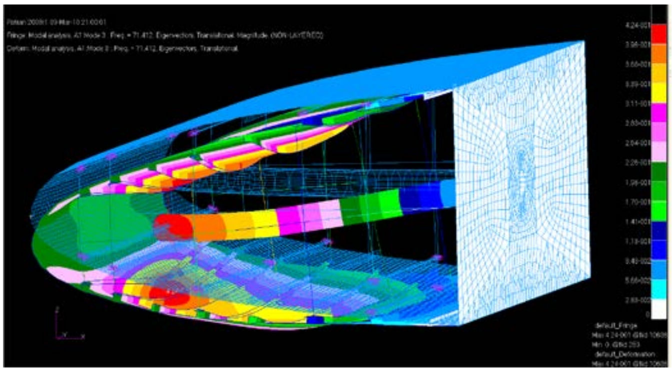


Compliant mechanism demonstrator (Source: CIRA)

Eccentric Beam

In a complementary study, the eccentric beam actuation mechanism for the SLE is investigated. The beam 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.

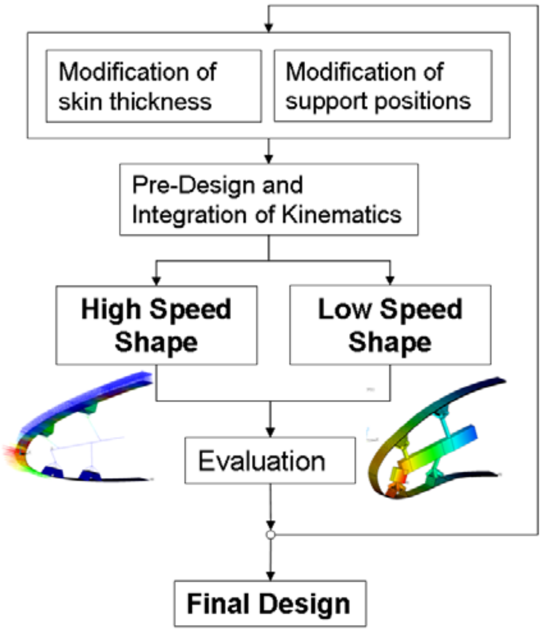
A geometrically nonlinear static analysis of the LE skin with integrated eccentric beam actuation mechanism was carried out, under the aerodynamic pressure, at both landing and cruise conditions. This study was conducted to demonstrate that the actuation mechanism provides enough support to the LE skin structure at different flight conditions. A static aeroelastic investigation showed that the material limit of 0.4% was not succeeded.



Elastic deformations in aeroelastic simulation (Source: CU)

Wind Tunnel Model

For the detailed design of the droop nose a refined design cycle has been established.

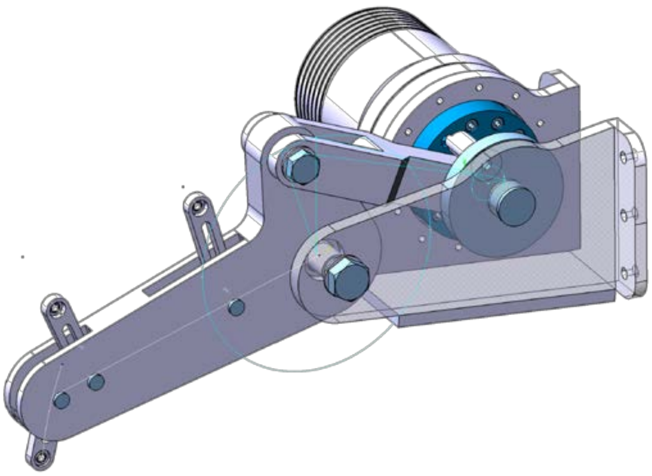


Smart leading Edge design cycle (Source: DLR)

The constraints of this cycle are cruise shape, target shape and initial skin thickness. Design variables are skin thickness (@18 positions in chord), number and position of support points in span and chord as well as the hinge points and angles of the kinematics. The procedure of the cycle is accounts for both high speed cruise flight and low speed flight.

To deform the skin altogether 10 internal kinematic sections are required. For the pre-design of the kinematics a simplified active framework for FE analysis with an approximation of the trajectories with circular arcs is used. The aim is to consider available design space and manufacturing constraints in order to minimize deviation from optimal kinematical path. A gradient based iterative optimization of the design variables results in a “best fit shape” that slightly deviates from the target shape. The deviation of the “best fit shape” is influenced by factors as aerodynamic loading, manufacturing constraints, strength requirements and the pre design kinematics.

For strength analysis both a material testing as well as simulations has been performed. The use of special GFRP and appropriate laminate design techniques keeps the maximum value of the Max-Strain criterion below 0.45%.

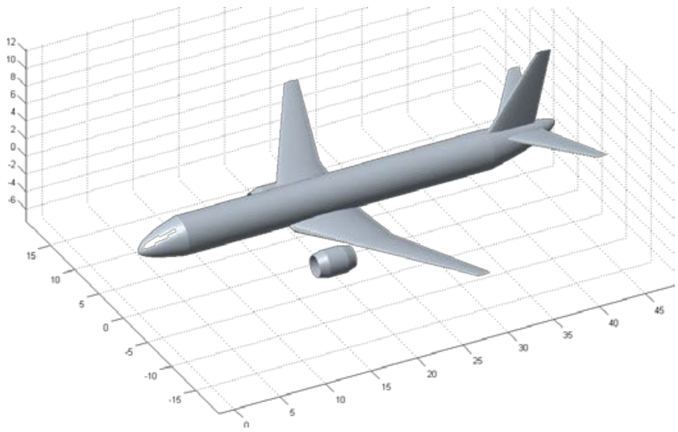


Model of the actuation mechanism for the droop nose
(Source: EADS)

The drooping motion is achieved by gearing the rotational output of a driving motor. The mechanical setup prevents the motor from holding large torques when the droop-nose is stationary positioned and aerodynamically loaded. For this a lever has been developed which acts via an eccentric. When the droop nose rotates to its fully deployed position of approx. 18 degree, the motor will rotate more than 2000 degrees. Aiming for a high precision motion (mostly by avoiding additional stress within the highly loaded skin) a stiffness analysis of the actuation mechanism was performed. Maximum deflection under loads is approx. 1.1 mm, distributed evenly over the lever and the bracket.

Work related to Concept Evaluation

One goal of current works is to evaluate the different concepts developed within SADE on an aircraft level. For this reason it is needed to model the high-lift system on subsystem respectively on component level. Due to the innovative character of the different SADE systems, a model based on semi-empirical analysis is not sufficient. Further specification of each concept including the components is required for the successful integration of the SADE systems. First components of the different systems have been modelled. Reference plane / Reference aircraft is a generic single-aisle body with circular cross-section (similar diameter as A320-family) with accommodation for 185 PAX in standard layout and 12 LD3-45W ULD using the FNG wing. A high-lift model based on the major system components for the conventional reference system containing slats and single-slotted fowler flaps with standard hydraulic actuation is the base line.



Reference aircraft model for device evaluation (Source: RWTH)

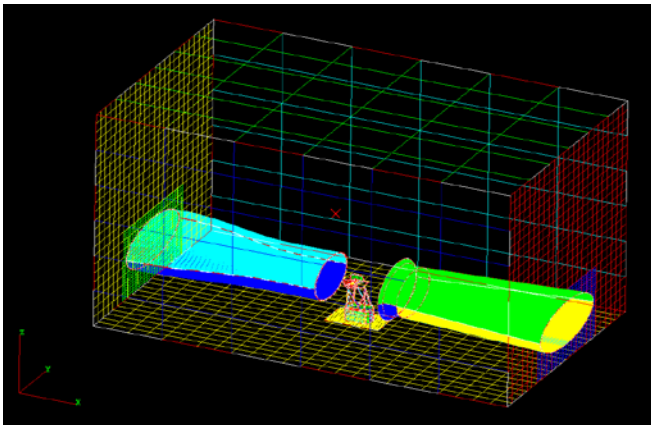
The evaluation will consider the impact of the new devices on the entire aircraft systems architecture like sizing of electrics and hydraulics and pneumatics as well as the impact on power off-takes and block fuel for new
systems architecture.

Selected Results of 3rd year

Work related to the wind tunnel model

Preparation

According to the results of the aerodynamic investigations for loads and shapes the structural design for the wind tunnel model is carried out. This involves the structural design of the wing section consisting of smart leading edge, wing box and trailing edge flap as well as the end plates and all other parts down to the connection to the wind tunnel mount. Additionally, to ensure safe operation a complete aeroelastic and aerodynamic design of the wind tunnel test section is required. The flutter stability is secured on the one hand and on the other hand the influence of the tunnel and the aspect ratio of the model with its end plates can be investigated.



Aeroelastic model of wind tunnel experiment with open section (source: FOI)

The wind tunnel model itself will be a five meter section of a FNG wing with a chord of 3 meters and a rectangular plan form. It will be equipped with a flexible nose and a conventional flap, which can be placed into cruise, take off and landing position. The wing box and the flap are conventionally manufactured of metal, the skin of the nose is made of GFRP as the flexibility and at the same time the strength of this skin is crucial for the success of such a gapless droop nose. The model will be instrumented with three sections of pressure tubes and strain gauges within the morphing part of the model and the kinematics. It is planned to use optical measurements to evaluate the displacement of the leading edge under loading conditions.

Hardware

Currently the hardware is being manufactured by different partners: DLR provides the leading edge skin, EADS IW supplies the kinematics, the trailing edge with

Leading edge skin (DLR), closure flap ribs (PAI), kinematics (EADS), wing box (TsAGI)

the flaps and the mounting plates are manufactured by Piaggio and the wing box and side plates as well as the connections to the mount of the wind tunnel are manufactured by TsAGI. Assembly of the different parts is an ongoing task presently at EADS and later at TsAGI.

Droop nose design for wind tunnel

As the flaps and wing box are rather conventional in their design, the seamless smart leading edge is designed flexible enough to be morphed into the take off and landing shape, but strong enough to carry the aerodynamic loads into the substructure and to bare the strains of morphing. In order to do so, a skin design process is established, which allows to tailor the skin thickness in a way that the displacements introduced by the kinematics will morph the skin into the desired shape. Also the load introduction into the skin is of interest. In the end omega stringers were designed to distribute the load of morphing deflections into the skin, taking into account the stringers stability and strength. The difference between the aerodynamically wanted target shape and the achieved shape is within tolerable limits. Besides the skin it is an important task to design the kinematics to deploy to a position of approx. 18 degrees. The kinematics has to follow the trajectories given from structural investigations of the skin with minimum deviations, allow continuous movement (no raster) and it has to keep driving moments low for fully retracted and fully deflected position. Another requirement is to keep only one actuation per span wise station. The results of the skin and kinematic design were combined and a final strength calculation was carried out.

Materials and structures

A crucial part of all morphing structures are the materials and structures that allow the morphing on one hand but at the same time carry loads. Several activities within SADE deal with such materials and structures. Selected results are presented in this section.

Flexible matrix composites

To reduce system-complexity of a droop nose with compliant mechanism an idea is to continuously support the skin through a system of inflatable actuation-tubes.This actuation concept will work pneumatically and make use of flexible matrix composites (FMC).

These FMCs are a combination of highly flexible materials such as rubber and very stiff continuous fibres (carbon or glass fibres). These materials enable a high flexibility in one direction while being very stiff in the other. Combining a tube-like geometry and a variable fibre-angle lay-up enables a wide range of deformation possibilities. An intense study on the possible material combinations for the manufacturing of FMCs and the production methods thereof were carried out by EADS, testing rubber, silicone and thermoplastic elastomer matrices with carbon fibres using different production methods. One focus was to create the production capability for large quantities of easy to use off-the-shelf material, similar to prepreg material for “classical” composite materials. Test specimen based on the gained knowledge were manufactured and characterized for mechanical properties.

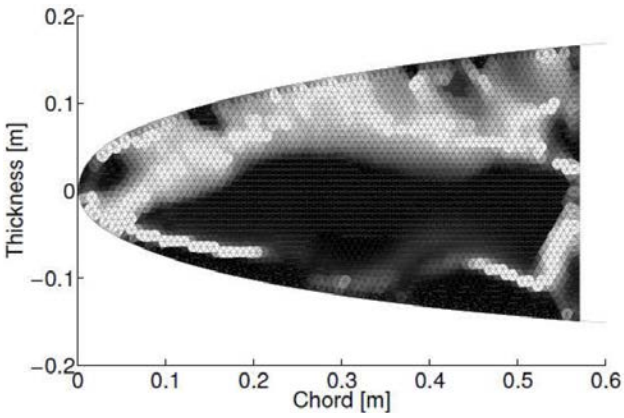
FMC-UD-prepreg (source: EADS)

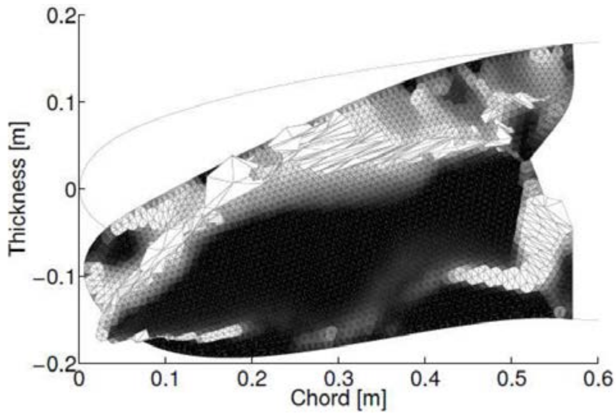
The results are twofold, on the one hand a technology is identified with which FMC can be reliably produced and on the other hand a suitable material-combination is found. The experiments with the various production processes and materials proved pultrusion and pressure moulding as the leading technologies to create flexible matrix composites. Especially pultrusion enables the production of a constant quality of prepreg FMCs.

For pressure moulding to become a viable production technique a way has to be found to properly restrain the fibers to avoid ondulations. If the fiber-placement could be ensured pressure moulding could still not be used to create the finished product. It is still necessary to first create a wrought material with which the final layup is realized.

Variable stiffness skin

Another activity within the project is dealing with tailored variable stiffness skins and actuation topologies as a solution to the dilemma of having a high stiffness to withstand aerodynamic loading, and low stiffness to enable morphing. Such a variable stiffness skin is achieved by a spatial fibre angle and skin thickness variation. The tailored stiffness distribution beneficially influences the structural deformation. A realistic skin stiffness is designed by TUD while taking the actuation and varying aerodynamic loads into account. On top of this skin optimisation a combined skin/actuation topology optimisation was carried out for the leading edge of the FNG wing – for now neglecting aerodynamic loads. For the topology optimisation a fixed region (connection to the spar) and the position of the actuation load are given. The actuation element density is optimized considering skin strain constraints. The results are 2D stiffness distributions over the leading edge, which indicate regions for hinges and levers. Hinge locations are predicted by the optimiser as areas with a reduced stiffness. Such an optimisation result can be seen in the following figures. Such optimistions are very useful to simulate and to design next generation leading edge topology.

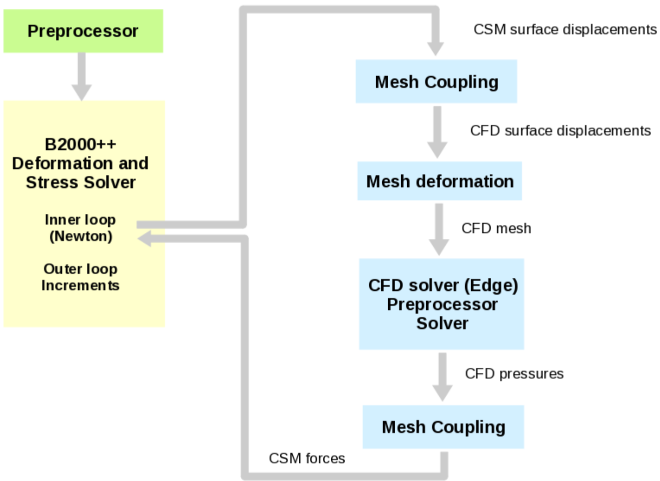




Deformed and undeformed actuation topology (source: TUD)

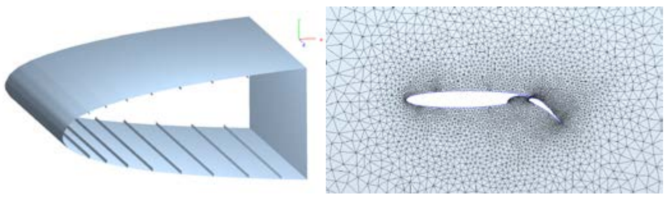
Virtual Aircraft

Besides the analysis of individual concepts there is an activity within SADE to establish a tool chain for coupled fluid-structure analysis in the range of medium to high fidelity analysis, executing nonlinear aero structural analysis loops and calculating deformed shapes and stresses under structural loads and flow parameters variations. In addition, the tool extracts aerodynamic performance data, such as c_p, for the selected flow parameter variations.



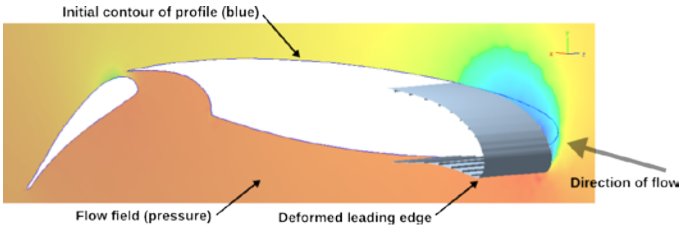
Schematic view of virtual aircraft tool chain (source: SMR)

Starting from structural FE model, wing profile data, and aerodynamic parameters, the tool attempts to automate the analysis process. In the current version the 2D fluid mesh and the FE model for mesh deformation are generated automatically. The mesh deformation model is the same as the aerodynamic mesh but the elements are specifically devised 'mesh deformation elements'.



FE model (left) and CFD model (right) (source: SMR)

Fluid-structure coupling is based on a promising novel approach, the 'common mesh refinement' method, which allows for smooth field transfer, preserving forces and moments. The field transfer process is integrated in the structural code in the form of special field transfer surface elements, which are solved together with the structural elements. The tool chain is now capable of carrying out droop nose deformation analysis with aerodynamic loads applied. This is illustrated with an analysis of one of the wing profiles studied within SADE (DLR F15 profile with flaps deployed) and a deformable leading edge (Cranfield structural model).

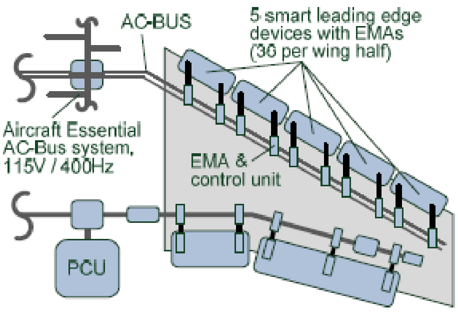


Coupled deformation analysis of droop nose (source: SMR)

The goal of the analysis is to calculate deformation and stresses of the structure under aerodynamic and structural loads, the actuation loads being defined by boundary conditions causing large deformations of the leading edge and by the aerodynamic loads of the deformed wing profile. The tool loops automatically over discrete values of the angle of attack analysis parameter, producing synthesis plots such as lift coefficient against angle of attack plot.

Concept Evaluation

To round up the project an evaluation of these concepts on an aircraft level is developed. The ILR Preliminary Aircraft Design Suite was enhanced so that it can estimate such influences. To do that a high-lift model, based on the major system components for the conventional reference system containing slats and single-slotted fowler flaps with standard hydraulic actuation is established.

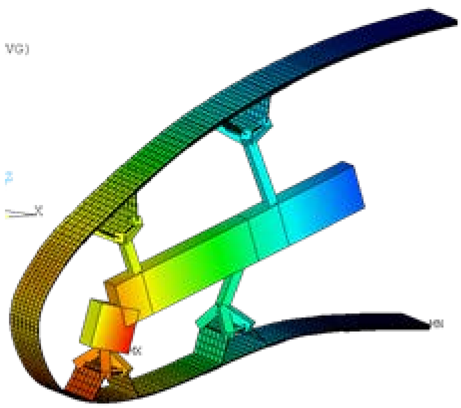


System Topology for the kinematic Chain Concept (source: RWTH)

This model is then implemented to the model for the entire conventional systems architecture of a transport aircraft. The modular implementation allows for an easy integration of innovative systems into the overall systems architecture. The model allows estimates on mass and energy consumption of the different aircraft systems, whereas the different energy systems (hydraulics, electrics and pneumatics) are sized by their consumers. The assessment on an aircraft-level becomes possible, since all repercussions of system integration are accounted for by the model.

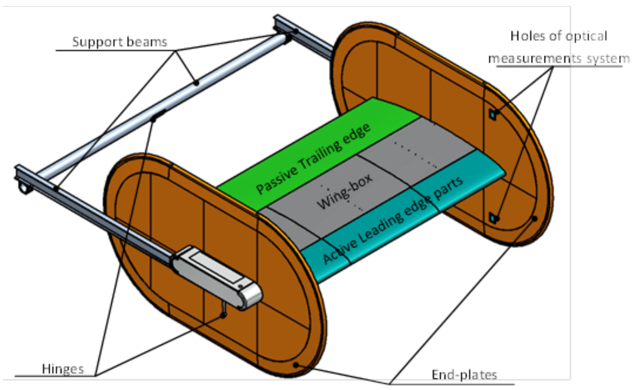
Selected Results of 4th and 5th year

The third period of the project is devoted to the wrap up of the detailed design but mainly focussed on the preparation and execution of the wind tunnel experiment with a full scale morphing stepless and gapless droop nose.



Simulation of displacements of droop nose (source: DLR)

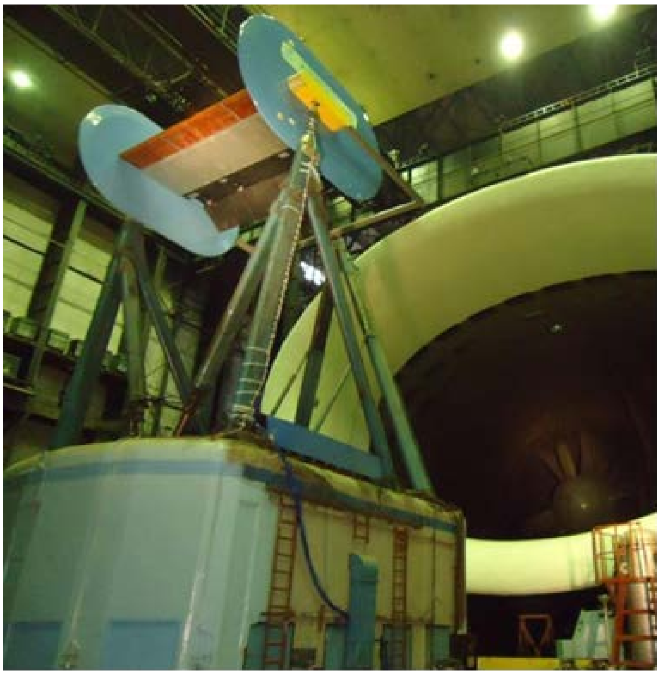
The wind tunnel model is equipped with a flexible nose part and a flap, which can be placed into cruise, take off and landing position. The seamless smart leading edge is designed flexible enough to be morphed into the take off and landing shape, but strong enough to carry the aerodynamic loads into the substructure and to bare the strains of morphing. In order to do so, a skin design process is established, which allows to tailor the skin thickness in a way, that the displacements introduced by the kinematics will morph the skin into the desired shape. Also the load introduction into the skin is of interest. In the end omega stringers were designed to distribute the load of morphing deflections into the skin, taking into account the stringers stability and strength. The difference between the aerodynamically wanted target shape and the achieved shape is within tolerable limits. Besides the skin it is an important task to design the kinematics to deploy to a position of approx. 18 degrees. The kinematics has to follow the trajectories given from structural investigations of the skin with minimum deviations, allow continuous movement (no raster or holding / breaking mechanisms) and it has to keep driving moments low for fully retracted and fully deflected position. Another requirement is to keep only one actuation per span wise station. The results of the skin and kinematic design were combined and a final strength calculation was carried out.



Wind tunnel model schematics (source: TsAGI)

The wind tunnel model is a rectangular wing of 5 m span and 3 m chord with constant profile and no taper. It consists of a main wing box (designed and built by TsAGI), which is used to mount the model to the wind tunnel base including the balance. Attached to this is a trailing edge with flap (designed by Piaggio), which can be put into different positions for take-off, landing and cruise. The droop nose itself, which was put into the leading edge was design and manufactured by DLR (skin) and EADS (kinematics and assembly). Final assembly and functional testing were carried out at TsAGI. In order to keep a more 2D like flow, two side plates (designed and built by TsAGI) – three meters high and five meters deep were mounted on either side of the wing section.

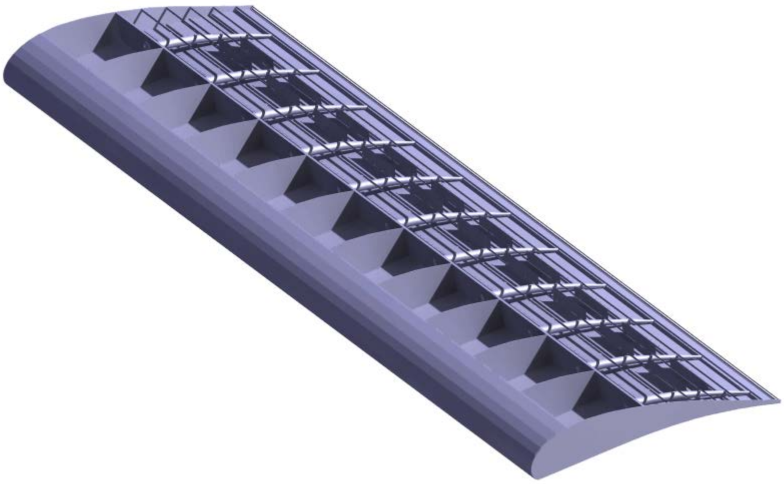
A test matrix of various wind speeds between 30 and 50 m/sec is run, varying the angle of attack between -10° and +22°. Three configurations are distinguished: take off (nose drooped, trailing edge flaps in take-off position), cruise (nose clean, trailing edge flaps retracted) and landing (nose drooped, trailing edge flaps in landing position. The model is equipped with three sections and a total of 58 strain gauges to measure the strain distribution in the skin, 16 strain gauges on the kinematics. The pressure distribution is measured by 3 sections of pressure tubes with 84 positions each. In addition an optical measurement technique is used to measure the deflections of the droop nose under aerodynamic loading.



Model installed in wind tunnel WT-101 (source: TsAGI)

The campaign is carried out in TsAGIS very large WT-101 near Moscow, with an elliptic nozzle that measures 14 x 24 m. The goal of this campaign is a structural prove, that the morphing GFRP skin in capable to be changed in contour significantly, but still caries all aerodynamic loads – this is why a full scale model was required. On the other hand, the CFD predictions for the morphed airfoil were to be proven. The very successful outcome of this test was, that no structural damages of the highly stressed skins were detected, even after several hours of testing and several cycles of deforming the nose. The comparison with 3D CDF showed especially for lower angles of attack up to 10° a very good accordance with the experimental data.

Besides this major result there were several complimentary studies carried out with detailed morphing designs. One of them is the design manufacturing and testing of a fluidic actuation concept. Those actuators were able to droop the leading edge. It could be shown, that the interface between the actuator and the skin and its friction is of major importance for the performance of the system. The forces generated with three of those within SADE developed actuators succeeded to provide appropriate actuator stroke to reach the desired deformation of the nose.



Trailing edge flap with horn concept (source: CU)

One other focus for a complementary study is the evaluation of the horn concept to change the camber of a trailing edge flap. Simulations for a full scale flap have been carried out including structural design, aerodynamic CFD simulations and finally aeroelastics. The static aeroelastic analysis shows that the SSSF deflection remains very small in the order of a few millimetres even when the stiffness of the actuation beam stiffness is reduced to 10% of its original value. The results show that the converged shape of this multidisciplinary optimisation will be even less deflected; hence the aerodynamic benefit resulting from the morphed flap will not be affected. The static aeroelastic behaviour of the structure is satisfied.

It can be concluded, that SADE stands for a major step forward in the development and evaluation of the potential of morphing airframe technologies in the high lift area. The wind tunnel experiment can be considered a milestone for morphing technologies and showed that large deformations are possible even for load carrying structures in full scale. The next step has to be the prove, that demands from operation requirements such as bird strike etc. can be incorporated into such morphing leading edges as well. Finally SADE helped to build up and mature a vast amount of additional concepts for droop nose and trailing edge morphing, which might be eventually alternatives to the concept chosen for the wind tunnel experiment. Also tools are available now, that can evaluate the benefit of such systems on an overall aircraft design.

The potential impact (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

Contribution towards the expected impacts listed in the work programme

The objective of the THEME 7 '***Transport***' within the FP7 specific programme '***Cooperation***' is: '*Based on technological and operational advances and on the European transport policy, develop integrated, safer, "greener" and "smarter" pan-European transport systems for the benefit of all citizens and society and climate policy, respecting the environment and natural resources; and securing and further developing the competitiveness attained by the European industries in the global market*'. The SDAE proposal refers to the sub-theme '***Aeronautics and Airtransport***', for which the **actual work programme** addresses six **activities** in agreement with the Strategic Research Agendas of ACARE:

1. The Greening of Air Transport
2. Increasing Time Efficiency
3. Ensuring Customer Satisfaction and Safety
4. Improving Cost Efficiency
5. Protection of Aircraft and Passengers
6. Pioneering the Air Transport of the Future

As already stated in chapter 1.1 SADE will contribute to activities 1, 4 and 6. This chapter will explain in detail the projects contribution to the expected impact listed in the work programme. The technical explanation how the here named benefits will be achieved is presented in chapter 1.1.

SADE is a **collaborative project** (CP) addressing **focussed research** on morphing structures for high lift devices. The ambition is to enhance basic smart structures concepts up to realisation and validation at component level; hence, the objective of this **upstream research** activity is to improve the **technology base** with proven concepts and technologies. Analytical investigations considering free flight conditions are combined with experiments which culminate in a full scale wind tunnel test. The integration and validation at a higher integration level in terms of full scale flight tests in a following project are planned by the SADE exploitation management. A consequent funding and concentrated cooperation of European key players presumed, morphing wing structures can be realised for industrial use by the year 2020. Hence, SADE matches the definition of **Level 1** CPs well and the following discussion on SADE contribution to the work programme will emphasis on topics designated for this instrument.

The **ACTIVITY 7.1.1 '*The Greening of Airtransport*'** addresses measures for developing technologies to reduce the environmental impact of aviation with the aim to halve the emitted carbon dioxide (CO_2), cut specific emissions of nitrogen oxides (NOx) by 80% and halve the perceived noise. Research will focus on furthering green engine technologies including alternative fuels technology as well as improved vehicle efficiency of fixed-wing and rotary wing aircraft, new intelligent low-weight structures, and improved aerodynamics. Issues such as improved aircraft operations at the airport (airside and landside) and air traffic management, manufacturing, maintenance and recycling processes will be included.

The aim of the ACTIVITYs **AREA 7.1.1.1** '***Green Aircraft***' is to ensure more environmentally friendly air transport focussing on the greening of the aircraft performance. Research work will address a wide range of innovative solutions and technologies for the aircraft, its systems and components for optimum use of energy and reduction of pollution (noise and emissions). The expected impact is as follows:

1. To reduce fuel consumption and hence CO_2 emissions by 50% per passenger-kilometre.
2. To reduce NO_X emissions by 80% in landing and take-off according to ICAO standards and down to 5 g/kg of fuel burnt in cruise
3. To reduce unburnt hydrocarbons and CO emissions by 50% according to ICAO standards

4. To reduce external noise by 10 EPNdB per operation of fixed-wing aircraft. For rotorcraft the objective is to reduce noise foot-print area by 50% and external noise by 10EPNdB

SADE develops and investigates morphing structures. As explained in chapter 1.1.3 advanced structural concepts will be realised ranging from constructive techniques down to the technology of tailored composite materials. The challenge is the optimised combination of structural flexibility for enabling efficient shape adaptation with the lightweight optimised fulfilment of strength requirements. Especially the development of morphing high lift structures requires the consideration and utilisation of aeroelastic interactions. Thus, these SADE objectives, in special morphing structures, are explicitly named in the **TASK AAT.2007.1.1.2 '*Aerostructures*'**. The resulting SADE morphing high lift devices provide wing adaptation at a lower mass than conventional high lift devices do; especially if applied to next generation low drag wings (see chapters 1.1.1-1.1.3). A **reduced mass** contributes to fulfilling all listed impacts.

Morphing structures permit a versatile adaptation of shape. Like chapter 1.1.1 presents, this is the basis for slot less high lift devices of increased high lift performance. Even a seamless realisation is possible constituting a technology which is an **inevitable enabler for laminar wings** and therefore contributes to significantly reducing drag. Thus; morphing high lift devices are necessary for the realisation of next generation **low drag** wings and additionally permits active reduction of drag. In take off **steeper climb** is obtained whereas in approach the abandonment of the slat-gap reduces airframe **noise emission**. These SADE objectives are, explicitly including wing morphing, demanded by the **TASK AAT.2007.1.1.1 '*Flight Physics*'** and contribute to all itemised impacts.

The activation concepts discussed in chapter 1.1.3 permit the replacement of conventional drives by electrically driven actuators permitting **reduction of power consumption** following the 'all-electric-aircraft' concept. Due to the more direct and distributed actuation concept a simplified integration and **reduction of systems dedicated mass** is obtained. These topics are called by the **TASK AAT.2007.1.1.4 '*Systems and Equipment*'**. Reduction of power consumption and mass contributes to all impacts expected.

ACTIVITY 7.1.4 '*Improving Cost Efficiency*' fosters a competitive supply chain able to halve the time-to-market, reduce product development and operational costs, resulting in more affordable transport for the citizen. Research will focus on improvements to the whole business process, from conceptual design to product development, manufacturing and in-service operations, including the integration of the supply chain. It will include improved simulation capabilities and automation, technologies and methods for the realisation of innovative and zero-maintenance, including repair and overhaul, aircraft, as well as lean aircraft, airport and air traffic management operations.

The aim of **AREA 7.1.4.1 '*Aircraft Development Costs*'** is to ensure cost efficiency in air transport focussing on the reduction of aircraft acquisition costs. Research work will address a wide range of concepts, innovative solutions and technologies which will result in lower lead time and costs of the aircraft and its systems from design to production, including certification, with more competitive supply chain. The expected impacts are

1. To reduce aircraft development costs by 50%
2. To create a competitive supply chain able to halve time to market
3. To reduce travel charges

SADE employs a virtual development platform. To some extent the scientific fundamentals including multidisciplinary coupling have already been developed; but the utilisation and enhancement of the digital technologies is mandatory to create acceptance and to establish them as state-of-the-art tools. Thus; the advanced modelling, simulation and design procedures are important contribution to impact 1 ' *To reduce aircraft development costs by 50%*'. This objective is addressed in **TASK AAT.2007.4.1.1. '*Design Systems and Tools*'**.

AREA 7.1.4.2 '*Aircraft Operational Costs*' targets to ensure cost efficiency in air transport focussing on the reduction of aircraft direct operating costs. Research work will address a wide range of concepts, innovative solutions and technologies which will reduce weight, fuel consumption, maintenance and crew operational costs as main contributors. The following impacts are expected:

1. To reduce aircraft operating costs by 50% through reduction in fuel consumption, maintenance and other direct operating costs
2. To reduce travel charges

As explained in chapter 1.1 and already itemised within the discussion of ACTIVITTY 7.1.1, morphing high lift devices integrate additional functions into the structure leading to a **reduction of mass**. This is also demanded by **TASK AAT.2007.4.2.2 '*Aerostructures*'**. The integration of systems and light weight structures is also addressed by **TASK AAT.2007.4.2.4 '*Systems*'**. The simplification of the resulting system reduces **maintenance costs**; furthermore replacing electrical actuators by conventional drives reduces **power consumption**. The explained reduction of drag and explicitly morphing wings are itemised by **TASK AAT.2007.4.2.1 '*Flight Physics*'**. Thus; the reduction of mass, power consumption and drag contribute to impact 1 ' *To reduce aircraft operating costs by 50% through reduction in fuel consumption, maintenance and other direct operating costs* '.

ACTIVITY 7.1.6 '***Pioneering the Air Transport of the Future***' explores more radical, environmentally efficient, accessible and innovative technologies that might facilitate the step change required for air transport in the second half of this century and beyond. Research will address aspects such as new propulsion and lifting concepts, new ideas for the interior space of airborne vehicles including design, new airport concepts, new methods of aircraft guidance and control, alternative methods of air transport system operation and their integration with other transport modes.

The subsidiary **AREA 7.1.6.1 '*Breakthrough and Emerging Technologies*'** focuses on technology breakthroughs air transport relies on to be able to respond to society demands in the second half of this century. Research work will need to adopt a less evolutionary approach and take the risk of exploring more radical departures from conventional thinking which will be able to introduce revolutionary concepts in fundamental disciplines of aircraft design. The expected impact is contributions to setting the foundations of a technology base that might have the power to cause a step change in air transport in the **long term**.

Morphing is an upstream topic dedicated to visionary concepts. Free adaptation of shape hat the potential for fantastic applications and benefits; which are usually discussed from an aerodynamic point of view. Nevertheless, chapter 1.1 points out the elementary interdependencies: It is obvious that adaptation of shape has to be bought at the price of complexity and mass.

SADE develops technologies for shape adaptation of increased efficiency. The specified targets are challenging from a structural and systems point of view and the discussed structural technologies are radical. Based on SADE morphing high lift devices a breakthrough in drag reduction is feasible with a timeframe till 2020 for realisation. **The smart integration of optimised actuators into lightweight structures is the next step towards the long term visions of morphing aircraft**.

Morphing is explicitly named in **TASK AAT.2007.6.1.1 '*Lift*'**.

Besides the technical orientation of research the work programme intents to influence the **cooperation** within research. SADE accounts for the integration of small and medium sized enterprises (SME) and the cooperation with eastern European countries:

Two **SME**s participate in SADE: SMR engineering (SMR) of Switzerland and Aircraft Research Associated (ARA) from the Great Britain. Both companies are well established within the European research community and were introduced in chapters 2.2.10 (SMR) and 2.2.3 (ARA). SMR operates the central virtual development platform which is the backbone of the whole project. ARA introduces unique experiences concerning HARLS wings from the NACRE project.

TsAGI is the **Russian Central Aerohydrodynamic Institute** which provided innovative contributions to the 3AS project. TsAGI has a vital share within SADE with a focus in the fields of multidisciplinary optimisation tools and structural, wind-tunnel and flight testing techniques (in topic AAT.2007.4.1.1), aerostructures (in topic AAT.2007.4.1.2) and smart materials (in topic AAT.2007.4.2.6 and AAT.2007.6.1.4).

Dissemination

Regarding the dissemination activities within the project, there are several tasks, which are meant to reach public with the results:

External Homepage

The external Homepage can still be found under http://www.sade-project.eu. Since the last reporting period it has been continuously improved. The introduction page was revised and a short description of the work packages was added. Especially the section "publication" was continuously updated, which helps to give references to the latest results of the project. That way the effort for maintenance of the pages is kept small.

Image film

The making of a SADE image film is almost finished. The cost of the film will be covered by Airbus and DLR. Bock Film in Bremen has produced the film. It contains interviews, animations as well as film sequences of demonstrators and the WT model during testing in Moscow.

News Letter

A yearly SADE Newsletter was started to share recent results of the project. It is a four page DIN A4 sized brochure, which is mainly distributed via internet and is available on the SADE web page (http://www.sade-project.eu/sade/sade_public/Publications.html). The first issue was released in April 2009, the second in June 2010, the third in June 2011. It is planned to release one final issue beginning of 2012.

SADE NEWS

Smart High Lift Devices for Next Generation Wings

FP7-AAT-2007-RTD
Collaborative Level 1 Project

Grant Agreement no.: 213442
Start Date: 1. May 2008
End Date: 30. April 2012
Duration: 48 months
Coordinator: DLR

No. 3 | July 2010 – June 2011 | http://www.smr.ch/sade

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Preface

The first three years of the SADE project are over and all 13 partners are still working hard to reach the challenging research objectives. Besides a lot of theoretical studies on innovative concepts for next generation high lift devices and substructures for such systems there is also more and more work going towards the detailed design and manufacturing of hardware, especially for the wind tunnel model which will be investigated within SADE. Some selected results will be described consecutively.

Besides the actual research work, it is an important goal of the project to share the research results with the research community in Europe. That is why the consortia organized a dedicated SADE session on the 1st EASN Association Workshop on Aerostructures in October 2010 in Paris, presenting a wide spectrum of project results reaching from design strategies of high lift devices, the design of variable stiffness skins and selectively deformable structures up to aeroelastic and aerodynamic analysis of novel high lift devices. In a total of eight presentations the project was well represented and the corresponding proceedings will be published in international reviewed journals. Up to now over 20 publications have been released within SADE.

Work related to the wind tunnel model

Preparation

According to the results of the aerodynamic investigations for loads and shapes the structural design for the wind tunnel model is carried out. This involves the structural design of the wing section consisting of smart leading edge, wing box and trailing edge flap as well as the end plates and all other parts down to the connection to the wind tunnel mount. Additionally, to ensure safe operation a complete aeroelastic and aerodynamic design of the wind tunnel test section is required. The flutter stability is secured on the one hand and on the other hand the influence of the tunnel and the aspect ratio of the model with its end plates can be investigated.

Aeroelastic model of wind tunnel experiment with open section (source: FOI)

Frontpage of the third issue of the SADE NEWS

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H. P. Monner, J. Riemenschneider, "Morphing high lift structures: Smart leading edge device and smart single slotted flap", Aerodays 2011, 30th March - 1st April 2011, Madrid, Spain

Publications 2010

R Morishima, S Guo, N Di Matteo, S Ahmed, “A composite wing structure with morphing leading edge and flap”, World Journal of Eng, Vol. 7, No.4, 2010, pp.186-193
M. Kintscher, J. Riemenschneider, "Design of a Droop Nose Device in the EU FP7 project SADE", CADFEM Users Meeting 2010, Aachen, 03.-05. November 2010
P. Monner, J. Riemenschneider, "Background and recent results of the European project ‘Smart High Lift Devices for Next Generation Wings’", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
S. Ameduri, "A Smart Leading Edge Architecture aimed at Preserving Laminar Regime", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
M. Kintscher, O. Heintze, H. P. Monner, "Structural Design of a Smart Leading Edge Device for Seamless and Gapless High Lift Systems", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
T. Kühn, "Aerodynamic Optimization of a Two-Dimensional Two-Element High Lift Airfoil with a Smart Droop Nose Device", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
G. A. A. Thuwis, M.M. Abdalla, Z. Gürdal, "A Variable Stiffness Skin for Morphing High-lift Devices", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
G.A.Amiryants, V.A.Malyutin, V.P.Timohin, F.Z.Ishmuratov, "Selectively Deformable Structures for Design of Adaptive Wings "Smart" Elements", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
J. Kirn, T. Lorkowski, H. Baier, "Development of Flexible Matrix Composites (FMC) for Fluidic Actuators in Morphing Systems", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
M. Doreille, T. Ludwig, S. Merazzi, L. Cavagna, P. Eliasson," A Tool Chain for Aero-Elastic Simulations", 1st EASN Association Workshop on Aerostructures, 7-8 Oct 2010, Paris, France
Kintscher, M. "Experimental Testing of a Smart Leading Edge High Lift Device for Commercial Transportation Aircrafts" 27th Congress of the International Council of the Aeronautical Sciences (ICAS), 19 - 24 September 2010, Nice, France
Lammering, E. Anton, R. Henke, "Technology Assessment on Aircraft- Level: Modeling of Innovative Aircraft Systems in Conceptual Aircraft Design", 10th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference, Fort Worth, Texas, Sep. 13-15, 2010
D. Li, S. Guo, J, Xiang, N. Di Matteo, “Control of an Aeroelastic System with Control Surface Nonlinearity”, 51st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 12-15 Apr 2010, Orlando, FL
N. Di Matteo, S. Guo, S. Ahmed, D. Li, “Design and Analysis of a Morphing Flap Structure for High Lift Wing”, 51st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 12-15 Apr 2010, Orlando, FL
Morishima, S. Guo, S. Ahmed, “A Composite Wing with A Morphing Leading Edge”, 51st AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 12-15 Apr 2010, Orlando, FL
G. A. A. Thuwis, M. M. Abdalla, Z. Gürdal, "Optimization of a variable-stiffness skin for morphing high-lift devices", Smart Mater. Struct. 19 124010 doi:10.1088/0964-1726/19/12/124010 , 2010

Publications 2009

G. A. A. Thuwis, R. De Breuker, M. M. Abdalla, Z. Gürdal. “Adaptive and Variable Stiffness Materials for Next Generation Morphing High-lift Devices”, 20th International Conference on Adaptive Structures and Technology, Hong Kong, 2009

D. Steenhuizen, M.J.L. van Tooren, R. Vos, "The application of Knowledge Based Engineering Techniques in smart concept selection for a novel high lift system", 20th International Conference on Adaptive Structures and Technologies,Hong Kong, 2009.

D. Steenhuizen, M.J.L. van Tooren, "An Automated Design Approach for High-Lift Systems incorporating Eccentric Beam Actuators", 13th AIAA/ISSMO Multidisciplinary Analysis Optimization Conference, Fort Worth, TX, USA, September 13-15 2010

SADE

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4.2 Use and dissemination of foreground

Section A (public)

TEMPLATE A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, STARTING WITH THE MOST IMPORTANT ONES										
NO.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Year of publication	Relevant pages	Permanent identifiers[1] (if available)	Is/Will open access[2] provided to this publication?
1	*Design of a smart leading edge device*	*M. Kintscher*	*Research Topics in Aerospace: Adaptive, Tolerant and Efficient Composite Structures*	*2012*	*Springer*	*Heidelberg, New York Dordrecht London*	*2012*	381-390	ISBN 978 3 642 29189 0	no
2	*Optimization of a variable-stiffness skin for morphing high-lift devices*	*G A A Thuwis*	*Smart Materials and Structures*	*Issue 12 (December 2010)*	*IOP Publishing*	*United Kingdom*	*2010*	-	*doi:10.1088/0964-1726/19/12/124010*	*no*
3	*The implementation of a knowledge-based framework for the aerodynamic optimization of a morphing wing device*	*Durk Steenhuizen*	*Advanced Engineering Informatics*	*26 (2012)*	*Elsevier*		*2012*	*207-218*	*doi:10.1016/j.aei.2012.02.004*	*no*
4	*A composite wing structure with morphing leading edge and flap*	*R Morishima*	*World Journal of Eng*	*Vol. 7, No.4,*			*2010,*	*pp.186-193*		*no*

[1] A permanent identifier should be a persistent link to the published version full text if open access or abstract if article is pay per view) or to the final manuscript accepted for publication (link to article in repository).
[2] Open Access is defined as free of charge access for anyone via Internet. Please answer "yes" if the open access to the publication is already established and also if the embargo period for open access is not yet over but you intend to establish open access afterwards.

5	*Nonlinear aeroelastic analysis of a morphing flap*	*D Li*	*International Journal of Bifurcation and Chaos*	*Vol. 22, No. 5*			*2012*	*pp. 1250099.1-11*		
6	*Multi objective optimization of a composite wing subject to strength and aeroelastic constraints*	*Guo S, Li D, Liu Y*	*J of Aerospace Engineering*	*vol. 226, 9 (2012)*	*SAGE*	*UK*	*01/09/2012*	*1095-1106*	*doi: 10.1177/0954410011417789*	*No*
7	*Modelling and Nonlinear Aeroelastic Analysis of a wing section with morphing trailing edge*	*Li D*	*J of Aerospace Engineering*	*3,2012*	*SAGE*	*UK*	*01/03/2012*	*1-13*	*doi: 10.1177/0954410012438341*	*No*
8	*Study on conditions of chaotic motion of a two-dimensional airfoil in subsonic flow*	*Li D*	*Journal of Fluid & Structures*	*Volume 33, 8, 2012*			*01/08/2012*	*109-126*		*No*

TEMPLATE A2: LIST OF DISSEMINATION ACTIVITIES								
NO.	Type of activities[3]	Main leader	Title	Date/Period	Place	Type of audience[4]	Size of audience	Countries addressed
1	*Conference*	*G.A.A. Thuwis*	*20th International Conference on Adaptive Structures and Technology*	*2009*	*Hong Kong*	*Scientific Community (higher education, Research), Industry*	*80*	Hong Kong, European Countries and United States of America
2	Conference	D.Steenhuizen	20th International Conference on Adaptive Structures and Technology	2009	Hong Kong	Scientific Community (higher education, Research), Industry	80	Hong Kong, European Countries and United States of America
3	Conference	D.Steenhuizen	13th AIAA/ISSMO Multidisciplinary Analysis Optimization Conference	September 2010	Fort Worth, Texas	Scientific Community (higher education, Research), Industry	30	Fort Worth, Texas European Countries and other United States of America
4	Conference	Morishima	51st AIAA/ASME/ASCE/AHS/ASC Structures	April 2010	Orlando, Florida	Scientific Community (higher education, Research), Industry	30	Orlando Florida European Countries and other United States of America,
5	Conference	N. Di Matteo	51st AIAA/ASME/ASCE/AHS/ASC Structures	April 2010	Orlando, Florida	Scientific Community (higher education, Research), Industry	30	Orlando Florida European Countries and other United States of America
6	Conference	D.Li	51st AIAA/ASME/ASCE/AHS/ASC Structures	April 2010	Orlando, Florida	Scientific Community (higher education, Research), Industry	30	Orlando Florida European Countries and other United States of America
7	Conference	E.Lammering	10th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference	September 2010	Fort Worth, Texas	Scientific Community (higher education, Research), Industry	30	Fort Worth, Texas, European Countries and other United States of America
8	Conference	Gennady	the 27th International Congress of	September	Nice,	Scientific Community	30	France and other European

[3] A drop down list allows choosing the dissemination activity: publications, conferences, workshops, web, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters, Other.

[4] A drop down list allows choosing the type of public: Scientific Community (higher education, Research), Industry, Civil Society, Policy makers, Medias, Other ('multiple choices' is possible).

		Amiryants	the Aeronautical Sciences	2010	France	(higher education, Research), Industry		Countries and United States of America
9	Conference	M. Kintscher	27th Congress of the International Council of the Aeronautical Sciences (ICAS),	September 2010	Nice, France	Scientific Community (higher education, Research), Industry	30	France and other European Countries and United States of America
10	Conference	M.Doreille	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry	30	France and other European Countries and United States of America
11	Conference	J. Kirn	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry	30	France and other European Countries and United States of America
12	Conference	G.A. Amiryants	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry	30	France and other European Countries and United States of America
13	Conference	G.A.A. Thuwis	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry		France and other European Countries and United States of America
14	Conference	T. Kühn	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry		France and other European Countries and United States of America
15	Confernce	M. Kintscher	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry		France and other European Countries and United States of America
16	Conference	S. Ameduri	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry		France and other European Countries and United States of America
17	Conference	H.-P. Monner	1st EASN Association Workshop on Aerostructures	October 2010	Paris, France	Scientific Community (higher education, Research), Industry		France and other European Countries and United States of America
18	Conference	O. Heintze	Wissenschaftstag DLR - FA	2010	Braunschweig, Germany	Scientific Community (higher education, Research), Industry		Germany
19	Conference	M. Kintscher	CADFEM Users Meeting 2010	November 2010	Aachen, Germany	Scientific Community (higher education, Research), Industry		Germany and other European Countries and United States of America
20	Conference	H.-P. Monner	Aerodays 2011	March 2011	Madrid,Spain	Scientific Community (higher education, Research), Industry		Germany and other European Countries and United States of America
21	Conference	N. Di Matteo	52nd AIAA/ASME/ASCE/AHS/ASC Structures	April 2011	Denver, Colorado	Scientific Community (higher education, Research), Industry		Denver, Colorado, European Countries and other United States of America

22	Conference	N. Di Matteo	International Forum on Aeroelasticity and Structural Dynamics (IFASD),	June 2011	Paris, France	Scientific Community (higher education, Research), Industry		France and other European Countries and United States of America
23	Concerence	Tim Lammering publication.	3rd International Workshop on Aircraft System Technologies (AST 2011)	March 2011	Hamburg	Scientific Community (higher education, Research), Industry		Germany and other European Countries and United States of America
24	Concerence	Tim Lammering	11th AIAA Aviation Technology, Integration, and Operations (ATIO) Conference,	Sep. 20-22, 2011	Virginia Beach, VA,	Scientific Community (higher education, Research), Industry		United States of America and European Countries
25	Conference	M. Kintscher	Deutscher Luft- und Raumfahrtkongress	September 2011	Bremen, Germany	Scientific Community (higher education, Research), Industry		Germany and other European Countries and United States of America
26	Conference	M. Kintscher	Wissenschaftstag FA, DLR	October 2012	Braunschweig, Germany	Scientific Community (higher education, Research), Industry		Germany and other European Countries and United States of America
27	Conference	S. Ameduri	ICAST2012: 23rd International Conference on Adaptive Structures and Technologies	October 2012	Nanjing, China	Scientific Community (higher education, Research), Industry		China, European Countries and United States of America
28	Concerence	T. Kühn	30th Applied Aerodynamics Conference	25-28 June 2012	New Orleans, LA, USA	Scientific Community (higher education, Research), Industry		European Countries and United States of America
29	Concerence	Q Fu	ICMNMMCS-2012	18-20 June 2012	Politecnico di Torino, Italy	Scientific Community (higher education, Research), Industry		European Countries and United States of America
30	Concerence	Z. Sun	ICCE-20	21-27 July 2012	Beijing, China	Scientific Community (higher education, Research), Industry		China, European Countries, USA
31	Concerence	N. Di Matteo	53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference	23-26 April 2012	Honolulu, Hawaii, USA	Scientific Community (higher education, Research), Industry		United States of America and European Countries
32	Web	Coordinator / SMR	www.sade-project.eu	Since 2009	Internet	Any		World Wide
33	Web / Press release	Coordinator	http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10204/296_read-2107/year-all/	2012	Internet	Any		
34	Web / Press release	Coordinator	http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10081/151_read-2107/year-all/	2012	Internet	Any		

35	Web / Press release	Coordinator	http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10660/1147_read-4492/ (ILA-Sondersete Luftfahrtexponate)	2012	Internet	Any		
36	Web / Press release	Coordinator	http://www.dlr.de/media/desktopdefault.aspx/tabid-4985//8422_read-20647	2012	Internet	Any		
37	Web / Press release	Coordinator	http://www.dlr.de/dlr/desktopdefault.aspx/tabid-10496/801_read-4022/	2012	Internet	Any		
38	Web / Pictures for Press	Coordinator	http://www.flickr.com/photos/dlr_de/6052417324/	2012	Internet	Any		
39	Article	Coordinator	http://www.rd-aerospace.de/newsletter/Newsletter_5_Oktober_2012.pdf	2012	Internet	Any		
40	Flyer	Coordinator	http://www.dlr.de/fa/Portaldata/17/Resources/dokumente/2012/CE_Droop_Nose.pdf	2012	Internet	Any		
41	Flyer	Coordinator	http://www.dlr.de/dlr/Portaldata/1/Resources/documents/2012_1/ILA-Standfuehrer-2012_web.pdf	2012	Internet, ILA Berlin	Any		Germany, European Countries, world wide
42	Newsletter	Coordinator	Sade News Mai 2008	2008	Internet	Any		World Wide
43	Newsletter	Coordinator	Sade News Mai 2009	2009	Internet	Any		World Wide
44	Newsletter	Coordinator	Sade News July 2010	2010	Internet	Any		World Wide
45	Film	Coordinator / Airbus	Sade – a Collaborative Research Program	2012	-	Any		
46	Film	Coordinator	Das DLR auf der ILA 2012: Ein Rundgang - http://youtu.be/ti6qjPcTjbk	2012	Internet	Any		
47	TV clips	Coordinator	nano	13.09.2012 um 18.30 Uhr	3Sat (TV station)			
48	Exhibition	Coordinator	MAKS	08-2011	Moskau	Any		Russia, European Countries
49	Exhibition	Coordinator	ILA	09-2012	Berlin	Any		Germany, European Countries
50	Exhibition	Coordinator	Composite Europe	10-2012	Düsseldorf	*Scientific Community (higher education, Research), Industry*		Germany, European Countries
51	Exhibition	Coordinator	JEC	03-2011	Paris	*Scientific Community (higher education, Research), Industry*		France, European Countries

52	Thesis	Glenn Thuwis (TUD)	Topology and Material Optimisation of High-lift Devices under Aeroelastic Loading	4 June 2012	Delft	Any		

Section B (Confidential[5] or public: confidential information to be marked clearly)
Part B1

TEMPLATE B1: LIST OF APPLICATIONS FOR PATENTS, TRADEMARKS, REGISTERED DESIGNS, ETC.					
Type of IP Rights[6]:	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	Application reference(s) (e.g. EP123456)	Subject or title of application	Applicant (s) (as on the application)
Patent	*Yes*	*30/10/2012*	*EP12425175*	*System for the variation of the geometry of an airfoil*	*Applicant: CIRA, inventor Salvatore Ameduri*

[5] Note to be confused with the "EU CONFIDENTIAL" classification for some security research projects.

[6] A drop down list allows choosing the type of IP rights: Patents, Trademarks, Registered designs, Utility models, Others.

Part B2

Please complete the table hereafter:

Type of Exploitable Foreground[7]	**Description of exploitable foreground**	Confidential Click on YES/NO	Foreseen embargo date dd/mm/yyyy	**Exploitable product(s) or measure(s)**	**Sector(s) of application**[8]	**Timetable, commercial or any other use**	**Patents or other IPR exploitation (licences)**	**Owner & Other Beneficiary(s) involved**
	Ex: New superconductive Nb-Ti alloy			*MRI equipment*	*1. Medical* *2. Industrial inspection*	*2008* *2010*	*A materials patent is planned for 2006*	*Beneficiary X (owner)* *Beneficiary Y, Beneficiary Z, Poss. licensing to equipment manuf. ABC*

In addition to the table, please provide a text to explain the exploitable foreground, in particular:

- Its purpose
- How the foreground might be exploited, when and by whom
- IPR exploitable measures taken or intended
- Further research necessary, if any
- Potential/expected impact (quantify where possible)

[19] A drop down list allows choosing the type of foreground: General advancement of knowledge, Commercial exploitation of R&D results, Exploitation of R&D results via standards, exploitation of results through EU policies, exploitation of results through (social) innovation.

[8] A drop down list allows choosing the type sector (NACE nomenclature) : http://ec.europa.eu/competition/mergers/cases/index/nace_all.html

4.3 Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*

Grant Agreement Number:	213442
Title of Project:	SADE
Name and Title of Coordinator:	Dr. Hans Peter Monner

B Ethics

1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***0Yes xNo***
2. Please indicate whether your project involved any of the following issues (tick box) :	***YES***
RESEARCH ON HUMANS	
• Did the project involve children?	No
• Did the project involve patients?	No
• Did the project involve persons not able to give consent?	No
• Did the project involve adult healthy volunteers?	No
• Did the project involve Human genetic material?	No
• Did the project involve Human biological samples?	No
• Did the project involve Human data collection?	No
RESEARCH ON HUMAN EMBRYO/FOETUS	
• Did the project involve Human Embryos?	No
• Did the project involve Human Foetal Tissue / Cells?	No
• Did the project involve Human Embryonic Stem Cells (hESCs)?	No
• Did the project on human Embryonic Stem Cells involve cells in culture?	No
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	No
PRIVACY	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	No
• Did the project involve tracking the location or observation of people?	No
RESEARCH ON ANIMALS	
• Did the project involve research on animals?	No
• Were those animals transgenic small laboratory animals?	No
• Were those animals transgenic farm animals?	No

• Were those animals cloned farm animals?	No
• Were those animals non-human primates?	No
RESEARCH INVOLVING DEVELOPING COUNTRIES	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	No
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	No
DUAL USE	
• Research having direct military use	No
• Research having the potential for terrorist abuse	No

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	0	2
Work package leaders	0	5
Experienced researchers (i.e. PhD holders)	3	40
PhD Students	2	9
Other	14	98

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**5**
Of which, indicate the number of men:	5

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?	○ x	Yes No

6. Which of the following actions did you carry out and how effective were they?

	Not at all effective				Very effective
❑ Design and implement an equal opportunity policy	○	○	○	○	○
❑ Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑ Organise conferences and workshops on gender	○	○	○	○	○
❑ Actions to improve work-life balance	○	○	○	○	○

○ Other:

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?

- ○ Yes- please specify
- X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?

- ○ Yes- please specify
- ○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?

- X Yes- please specify: Film on high lift and SADE
- ○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?

- ○ Main discipline[9]: 2.3
- ○ Associated discipline[9]: 2.2
- ○ Associated discipline[9]:

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*	○ X	Yes No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?

- ○ No
- ○ Yes- in determining what research should be performed
- ○ Yes - in implementing the research
- ○ Yes, in communicating /disseminating / using the results of the project

[9] Insert number from list below (Frascati Manual).

11c	**In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?**	○ ○	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

- ○ No
- ○ Yes- in framing the research agenda
- ○ Yes - in implementing the research agenda
- ○ Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

- ○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
- ○ Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
- ○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- ○ European level
- ○ International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**7**
To how many of these is open access[10] provided?	**1**
How many of these are published in open access journals?	**1**
How many of these are published in open repositories?	
To how many of these is open access not provided?	
Please check all applicable reasons for not providing open access:	
x publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available ❑ no suitable open access journal available ❑ no funds available to publish in an open access journal ❑ lack of time and resources ❑ lack of information on open access ❑ other[11]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	**1**

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	
	Registered design	
	Other	

17. How many spin-off companies were created / are planned as a direct result of the project?	
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑ Increase in employment, or	❑ In small & medium-sized enterprises
❑ Safeguard employment, or	❑ In large companies
❑ Decrease in employment,	❑ None of the above / not relevant to the project
❑ Difficult to estimate / not possible to quantify	

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:*

[10] Open Access is defined as free of charge access for anyone via Internet.

[11] For instance: classification for security project.

Difficult to estimate / not possible to quantify	❑

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

○ Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

○ Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

❑	Press Release	X	Coverage in specialist press
❑	Media briefing	X	Coverage in general (non-specialist) press
X	TV coverage / report	❑	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
X	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

❑	Language of the coordinator	X	English
❑	Other language(s)		

Question F-10**:** Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]

2. FINAL REPORT ON THE DISTRIBUTION OF THE EUROPEAN UNION FINANCIAL CONTRIBUTION

Name of beneficiary	Final amount of EU contribution per beneficiary in Euros
1.*DLR*	
2.	
n	
Total	

Force not available right now.