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AFLoNext – A European Contribution to Airframe Noise Control

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ABSTRACT

AFLoNext is a project of four years duration, funded by the European Commission within the Seventh Framework Programme. The project's main objectives are proving and maturing highly promising flow control and noise reduction technologies for novel aircraft configurations, to achieve a big step forward towards improved aircraft's performance and thus reducing the environmental footprint. The project consortium is composed by 40 European partners from 15 countries. One of the six technology streams, which are forming the scientific concept of AFLoNext, is concerned about the mitigation of airframe noise during approach and landing, generated on flap and undercarriage and through mutual interaction. Following the success of previous achievements on European level, accomplished in projects such as TIMPAN, SILENCER and OPENAIR, low noise technologies for the reduction of landing gear/flap interaction and flap side edge noise are going to be further developed in wind tunnel testing with a common goal: The proof under real operational conditions in flight test at the end of the project.

This paper is to give an overview on the intended approach in AFLoNext and the expected results related to aircraft acoustics and impact on aerodynamic performance.

Keywords: Aircraft noise, airframe noise
I-INCE Classification of Subjects Number(s): 13.1.1, 13.1.5

1. INTRODUCTION

Within the European Union's Seventh Framework Programme for research, technological development and demonstration, AFLoNext (full project title: 2nd Generation Active Wing - Active Flow, Loads & Noise Control on Next Generation Wing) is a so-called large-scale integrating project with four years duration [1]. The main objective is proving and maturing highly promising flow control technologies for novel aircraft configurations and thus to achieve a major improvement of aircrafts' performance and thus reducing the environmental footprint.

The work within AFLoNext is broken down into seven work packages and the project's concept is based on six technology streams:

- Hybrid Laminar Flow technology applied on fin and wing for friction drag reduction.
- Flow control technologies applied on outer wing for performance increase.
- Technologies for local flow separation control applied in wing/pylon junction to improve the performance and loads situation mainly during take-off and landing.
- Technologies to control the flow conditions on wing trailing edges thereby improving the performance and loads situation in the whole operational domain.
- Technologies to mitigate airframe noise during landing generated on flap and undercarriage and through mutual interaction.
- Technologies to mitigate/control vibrations in the undercarriage area during take-off and landing.

AFLoNext aims to prove the engineering feasibility of the HLFC (hybrid laminar flow control) technology for drag reduction on fin in flight test and on wing by means of large scale testing as well as for vibrations mitigation technologies for reduced aircraft weight and for noise mitigation technologies.

2. NOISE CONTROL ON AIRFRAME IN AFLoNext

The project's work package no.4 "Noise Control on Airframe" is focused on the noise reduction for the two important sources

- Landing gear wake interaction with the flap.
- Flap side edge noise.

Landing gear wake flap interaction noise is comparable to slat noise in terms of source noise levels. Since the source region is very limited its contribution to the overall far field radiated noise is limited but not negligible. By means of a numerically optimized flap setting and landing gear treatments that tend to broaden the gear wake and thus reduce local flow velocities a substantial interaction noise reduction shall be achieved.

The flap side edge (FSE) represents one of the strongest airframe noise sources regarding source intensity. Due to this fact, and a pronounced lateral radiation characteristic, flap side edge noise contributes significantly to the overall airframe noise signature of transport aircraft. Porous flap side edge treatments are well known as suitable means to reduce flap side edge noise. Based on the available knowledge porous flap side edge treatments will be designed and manufactured for both, an airliner and a business jet.

2.1 Flap-Landing Gear Interaction

During the past decade several research projects founded by the European Commission aimed at the development of landing gear noise reduction technology. Based on the knowledge gained over the last 10-15 years in the former EC funded projects RAIN, SILENCER and TIMPAN low noise treatments for an Airbus A320 type main landing gear were designed and wind tunnel tested within the European project OPENAIR [2]. The respective large scale wind tunnel test on a full scale A320 landing gear mock-up in DNW-LLF wind tunnel revealed that mesh fairings and blocker plates are suitable means to reduce the main landing gear noise by up to 4 dB, with respect to the noise source. Based on the OPENAIR large scale wind tunnel tests mesh fairings and blocker plates represent TRL 5 noise reduction technology. Accordingly a system prototype demonstration within a flight test, as is planned for AFLoNext, would be the next step to increase the TRL.

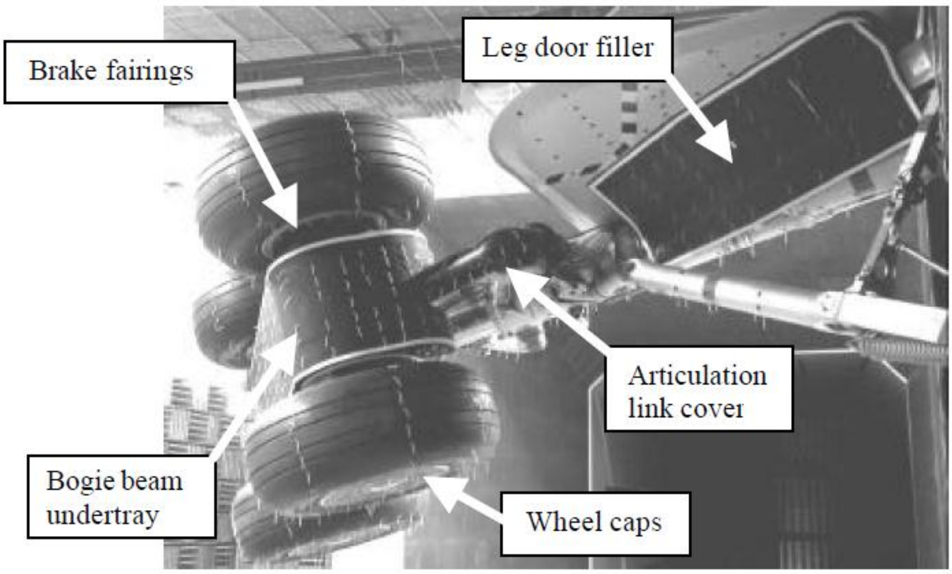

Figure 1 – Example for a low noise landing gear fairing [4]

The interaction of the landing gear wake with the flap is known as airframe noise source but was regarded as a kind of second order effect if compared to pure landing gear or high lift system generated noise. In case landing gear noise is substantially reduced by means of mesh fairings and blocker plates this interaction noise phenomenon is no longer a second order problem but has to be addressed. Based on the outcome of the FP5 project SILENCER it is known that the wake interaction with the flap leading edge is the most prominent noise source. The objective in AFLoNext is to minimize the gear wake flap interaction by means of an optimized flap setting. Therefore numerical flow simulations will be conducted. The finally defined optimized flap setting will be flight tested in combination with the low noise treatments mentioned above.

The main objectives regarding the landing gear activities are

- Landing gear noise reduction by means of add-on treatments and optimized flap deflection angle.
- Investigate the landing gear wake/flap interaction; definition of flap deflection angle for minimized interaction noise level.
- Design of an add-on treatment for landing gear noise reduction (mesh fairings, blocker plates).
- Flight test clearance and flight test of low noise landing gear.
- To reach TRL 5 to 6.

2.2 Porous Flap Side Edge

The flap side edges of conventional transport aircraft represent strong noise sources that contribute to the high lift system related airframe noise.

In previous European projects, e.g. RAIN and OPENAIR, it has been demonstrated that flap side edge noise can be significantly reduced with porous treatments [6,7]. While in RAIN basic principles of flap side edge noise generation and reduction had been investigated the work within OPENAIR focused on the choice of materials and the design of a flap side edge under consideration of airworthiness. The finally designed flap side edge prototypes were tested at a large scale high lift system in DNW-LLF. Again a significant noise reduction in the order of about 4 to 5 dB was achieved on noise source level. Based on the latest results the porous flap side edge technology will be ranked at TRL 5.

Figure 2 – Porous flap side edge treatments for assessment in wind tunnel test [7]

Even if the porous technology itself is very promising with respect to the potential noise reduction, the application on business jets and airliners are different due to the different particular wing design. Thus, the work is focused on the flight test, using a porous flap side edge on an Airbus A320 aircraft. Therefore the generic design from the OPENAIR project will be adapted to the specific design requirements of an Airbus A320 aircraft. The final goal is low noise flap side edge at TRL 6.

In addition, the design of a porous flap side edge for the application on a business jet is targeted. The well-known acoustic design requirements will be transferred from the airliner platform to the business jet flap. It is intended to manufacture and integrate a porous flap side edge onto a business jet flap.

So the overall objectives for the porous flap side edge in AFLoNext can be summarized:

- Large-scale wind tunnel test on porous flap side edge at an A320 flap geometry.
- Airworthiness demonstration of a porous FSE.
- Flight test clearance and flight test of FSE treatment on airliner to prove capability.
- Technology development towards TRL 5 to 6.

3. CURRENT STATUS AND FUTURE STEPS

In 2014 wind tunnel tests have been carried out during 2014 for final technology verification and to support the definition of the low noise configurations that will be implemented during the flight test for both, landing gear and porous flap side edge. Those configurations are currently under preparation, i.e. design, achieving the permission-to-flight and manufacturing. The flight test campaign will then be started in 2016.

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