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D6.8 - FINAL DISSEMINATION AND EXPLOITATION WORKSHOP

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Abstract

This deliverable D6.8 presents the minutes of the INVENTOR Final Dissemination and Exploitation Workshop that was held on October 22nd and 23rd, 2024, in the Novotel City Centre in Bucharest (Romania), homed by the 25th Annual Workshop of the Aeroacoustics Specialists Committee of the CEAS, which topic was especially redirected to "Airframe Noise Reduction: Needs, Challenges and Opportunities".

Keywords

H2020 project – Dissemination workshop

Information Table

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[1] Use one of the following codes: R=Document, report (excluding the periodic and final reports)
DEM=Demonstrator, pilot, prototype, plan designs
DEC=Websites, patents filing,press & media actions, videos, etc.
OTHER=Software, technical diagram, etc.

[2] Use one of the following codes: PU=Public, fully open, e.g. web
CO=Confidential, restricted under conditions set out in Model Grant Agreement
CI=Classified, information as referred to in Commission Decision 2001/844/EC.

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1 Context and organization

1.1 Grant Agreement

According to INVENTOR's Grant Agreement, "*at the end of the project, INVENTOR's* Communication Manager (ONERA) *will organise a dissemination and exploitation workshop targeting INVENTOR end-users to disseminate the results of the project according to the PEDR for further exploitation in new projects. The workshop will be organized aside an existing conference or event. The minutes of this workshop will be submitted as D6.8 Final Dissemination and Exploitation Workshop Minutes at M48.*"

1.2 Association with the CEAS-ASC workshop

During INVENTOR' TRM-PMM3 in Chalmers University (May 2023), the possible format and place of the workshop was discussed. Gareth Bennett (Trinity College Dublin), who is part of the CEAS-ASC Committee, reported that the Committee was currently discussing the topic and venue of their next workshop to be held in October 2024, and he suggested that our Dissemination Workshop could be associated to this CEAS-ASC Workshop. This proposal was considered by the INVENTOR's partners as excellent, and Gareth was kindly asked to present this idea at the next meetings of the Committee, which he did, obtaining a favourable feedback from the committee.

During the TRM of WP3/4/5 in TCD in April 2024, the possibility was discussed and approved again by the Consortium, and INVENTOR's coordinator was invited to next specific meetings of the Workshop Organization Committee led by Alan McAlpine (ISVR) with the active participations of Eugene Kors (SAE) and Dominique Collin, supported by colleagues at COMOTI (Luminita Dragasanu, Narcisa Burtea, Dan Radulescu) in charge of the local organization of the workshop in Bucharest, Romania. The final decision was taken to redirect the workshop's topic from "En-route noise" (linked to the future open fan engine implementations) to "Airframe Noise Reduction: Needs, Challenges and Opportunities" to fit INVENTOR's perimeter.

1.3 Full week of events

The date of Oct 22nd-23rd, 2024 was chosen with respect to the requirement of also holding, in the same week Oct 21st to 25th, several specific meetings organized by the Committee, and a public workshop organized by the UE PULSAR project. Consequently, the INVENTOR Consortium decided to hold its last TRM-PMM 4 at the same place on Oct 21st.

Finally, the agenda of the week was the following:

- Mon, Oct 21st: INVENTOR's TRM-PMM4 restricted to the INVENTOR Consortium and Advisory Board
- Tue-Wed Oct 22nd-23rd: 25th CEAS-ASC Workshop – The topic of this public workshop has been redirected to "Airframe Noise Reduction: Needs, Challenges and Opportunities" to serve as the contractual INVENTOR Dissemination Workshop, with 2 keynotes lectures and 11 technical presentations given by INVENTOR partners.
- Thu, Oct 24th morning: CEAS-ASC, ASD/EIMG, NFP/AVNEX meetings
- Thu, Oct 24th afternoon and Fri, Oct 25th morning: PULSAR public workshop

1.4 Workshop organization

1.4.1 Organising Committee

The Organising Committee was the following:

- Alan McAlpine (ISVR, UK)
- Roberto Camussi (Roma Tre University, IT)
- Dominique Collin (AVNeX, FR)
- Lars Enghardt (DLR, DE)

- Denis Gely (ONERA, FR)
- Attila Nagy (BME, HU)
- Christophe Schram (VKI, BE)

1.4.2 Local Organising Committee, web site, flyer

The Local Organising Committee was the following:

- Luminita Dragasanu (COMOTI, RO)
- Dan Radulescu (COMOTI, RO)
- Narcisa Burtea (COMOTI, RO)
- Constantin Sandu (COMOTI, RO)
- Eugene Kors (SAFRAN, FR)
- Eric Manoha (ONERA, FR)

INVENTOR's coordinator has been associated to weekly meetings of the organization committee, which first tasks were:

- to build a web site homed by COMOTI: https://comoti.ro/airframe-noise-reduction/
- to edit a flyer to be disseminated through the European aeroacoustic community (see Appendix).

1.4.3 Workshop Topics

The workshop topics to be covered included (but were not limited to):

- Understanding the physics of airframe noise generation
- Noise reduction of High Lift Devices and Landing Gears
- Low noise by design approach
- Add-on passive and active noise reduction technologies
- Experimental and numerical approaches
- Others

1.4.4 Scientific Committee

- Alan McAlpine (ISVR, UK)
- Roberto Camussi (Roma Tre University, IT)
- Denis Gely (ONERA, FR)
- Eugene KORS (SAFRAN, FR)
- Dominique Collin (AVNeX, FR)
- Eric Manoha (ONERA, FR)
- Michael Pott-Pollenske (DLR, DE)
- Gareth Bennett (Trinity College Dublin, IE)
- Dan Radulescu (COMOTI, RO)
- Luminita Dragasanu (COMOTI, RO)
- Laurentiu Cristea (COMOTI, RO)

1.4.5 Contributions from INVENTOR'

From the start, the INVENTOR's coordinator was asked to:

- inform the Project Officer at CINEA (Leonidas Siozos-Rousoulis) to get his formal approval on the principle of associating our Dissemination Workshop to the CEAS-ASC annual event (he was very positive and even formally accepted to give a talk in introduction of the workshop,
- inform the INVENTOR partners, and tentatively promote their contributions in terms of:
  - technical presentations, following a classic "call for papers" process to be initiated as soon as possible by the CEAS-ASC via a dedicated website and the dissemination of a flyer,
  - one or two possible keynote lectures, leading to suggesting the idea of INVENTOR's industrial partners giving the position of airframers on the significance of airframe noise,

- advise on a potential guest from outside Europe, possibly delivering a keynote lecture on the topic of airframe noise, leading to the proposal of Mitsuhiro Murayama (senior scientist at JAXA).

Finally, the workshop contained:

- 3 keynotes lectures given by (i) the INVENTOR Project Officer Leonidas Siozos-Rousoulis, CINEA, (ii) INVENTOR industrial partners A. Scotto (Airbus), V. Fleury (Dassault-Aviation) and A. Ghouali (Safran Landing Systems) and (iii) an invited scientist (Mitsuhiro Murayama, JAXA)
- 16 technical presentations, including 12 from INVENTOR.

In more details, the contributors from the INVENTOR project were the following (note that only the first author or presenter and a short title are mentioned):

- Introduction
  - INVENTOR Overview (E. Manoha - ONERA)
- 2 keynote lectures
  - INVENTOR in H2020 (L Siozos-Rousoulis – CINEA)
  - Vision from the industry (A. Scotto - AF, V. Fleury - DAV, A. Ghouali - SLS)
- 5 technical presentations on Landing Gear Noise Reduction technologies:
  - LG-flap interaction (M. Fuchs – UPCFD)
  - 4-wheel vs 2-wheel MLG (L. Sanders – ONERA)
  - Scale effect on LG tests (A. Ghouali – SLS)
  - Flow through fairings for LG (R. Zamponi – TUD-VKI)
  - Air curtain (G. Bennett – TCD)
- 6 technical presentations on High Lift Devices Noise Reduction technologies:
  - Slat porous inserts (M. Pott-Pollenske – DLR)
  - HLD (slat track) noise prediction with LBM (M. Soni – DLR)
  - Krüger slat noise (L. Sanders – ONERA)
  - Spoiler noise simulation with LBM (T. Gianoli – CERFACS)
  - Spoiler noise measurements (D. Angland, SoU)
  - Slat track noise measurements/simulation (E. Manoha – ONERA)

1.4.6 Workshop final program

The Workshop program was organized on 2 days with an introductive session, two main lecture notes and 4 technical sessions of 4 presentations each. Presenter's name is underlined.

Summaries of all INVENTOR's presentations (and main technical questions raised by the audience) are gathered in the appendix.

Day 1 – Tuesday 22th October

9:00 – 9:30	*Registration & Welcome coffee*
9:30 – 9:40	*Welcome from the Ministry Of Research, Innovation And Digitalization* Minister Bogdan-Gruia Ivan
9:40 – 10:00	*Welcome to the workshop* Valentin Silivestru, President - General Manager of INCD-T COMOTI Roberto Camussi (RomaTre), Chair of CEAS-ASC Committee [Online]

10:00 – 10:15	*INVENTOR Overview* Eric Manoha (ONERA), Coordinator of INVENTOR
10:15 – 10:30	Keynote presentation *"The contributions of INVENTOR to H2020"* Leonidas Siozos-Rousoulis, Project Officer from EC/CINEA [Online]
10:30 – 11:00	*Coffee break*
11:00 – 13:00	Session 1. Chair – Gareth Bennett (TCD), 120 mins. *Two numerical studies of landing gear wake / flap interaction noise* M. Fuchs (UpstreamCFD), J. Dierke, R. Ewert, M. Pott-Pollenske, C. Mockett and J. Delfs *4-wheels landing gear noise impact assessed by LBM simulation* L. Sanders (ONERA) *Aeroacoustic analysis of a fuselage-wing-slat junction in approach configuration* H. Piera (MuTech), R. Zamponi and F. Hartog *A new concept for the source localization of airframe noise* J. Delfs (DLR)
13:00 – 14:00	*Lunch*
14.00 – 15.00	Keynote lecture 1 Chair – Eric Manoha (ONERA), 60 mins. *"JAXA's Research Activities Toward Airframe Noise Reduction"* Mitsuhiro Murayama (JAXA)
15.00 – 15.30	*Coffee break*
15:30 – 17:30	Session 2. Chair – Aline Scotto (Airbus), 120 mins. *The use of different air curtain nozzles to reduce the aerodynamic noise radiated from a modified LAGOON landing gear* G. Bennett (TCD) *Noise source analysis of flow-permeable fairings in the LAGOON landing gear model* R. Zamponi (Delft U.), A. Rubio-Carpio, F. Avallone and D. Ragni *Using Combined Vacuum and Leading-Edge Vibration Technology for Shock Wave Mitigation at the European Supersonic Aircraft* C. Sandu (COMOTI), A. Totu, C. Olariu and A. Trifu *Airframe Noise of an A320 and Low Noise Technology: Simulation and Flyover Experiment* S. Proskurov (DLR), M. Mößner, R. Ewert, J. Delfs, J. Dierke, M. Pott-Pollenske and D. Almoneit
17:30	*Close of day 1*
19:00	Workshop dinner

Day 2 – Wednesday 23th October

9:00 – 9:30	Welcome coffee
09:30 – 10:30	Keynote lecture 2 Chair – Eugene Kors (Safran Aircraft Engines), 60 mins. *"Needs, challenges and opportunities" in the field of airframe noise* Aline Scotto (Airbus), Vincent Fleury (Dassault-Aviation) and Amine Ghouali (Safran Landing Systems)
10:30 – 11:00	Coffee break
11:00 – 13:00	Session 3. Chair – David Angland (UoS), 120 mins. *Comparison of trailing arm main landing gear wind tunnel noise measurements at different scales* A. Ghouali (Safran Landing Systems) and V. Fleury *CFD/CAA Investigation of Krueger Slat Noise Reduction Based on an Existing Experimental Database* L. Sanders (ONERA), T. Renaud, S. Li, S-H. Peng and M. Pott-Psollenske *Numerical Investigation of Airframe Noise with the Lattice Boltzmann Method: Application to Spoiler Generated Noise* T. Gianoli (CERFACS) and J-F. Boussuge *Effect of a Lifting Wing on Spoiler Noise* O. Parnis and D. Angland (UoS)
13:00 – 14:00	*Lunch*
14:00 – 16.00	Session 4. Chair – Jan Delfs (DLR), 120 mins. *Using of Vacuum Technology for Noise Reduction of Slats and Landing Gears at Aircraft* C. Sandu (COMOTI), A. Totu, C. Olariu and A. Trifu *On the Prediction of Complex High-Lift Noise and Prospects of Noise Reduction Technology using the Lattice Boltzmann Paradigm* M. Soni (DLR), R. Ewert, M. Pott-Pollenske and J. Delfs *The Challenge of Slat Noise Reduction by retro-fit Technology* M. Pott-Pollenske (DLR) and M. Jansen *Slat track noise and flow measurements in noisy aerodynamic closed section windtunnel and associated CFD/CAA computations* R. Davy, E. Manoha (ONERA) and M. Terracol
16:00 – 17:00	*Closing remarks at end of workshop/Closing reception*

1.5 Participants list

44 participants were registered to the workshop.

David Angland	Univ. of Southampton	Andrei Totu	COMOTI
Aline Scotto	AIRBUS	Claudiu Capra	COMOTI
Eric Manoha	ONERA	Eugene Kors	SAFRAN
Denis Gely	ONERA	Mitsuhiro Murayama	JAXA
Laurent Sanders	ONERA	Valentin Silivestru	COMOTI
Stanislav Proskurov	DLR	Luminita Dragasanu	COMOTI
Malav Soni	DLR	Narcisa Burtea	COMOTI
Amine Ghouali	SAFRAN	Dan Radulescu	COMOTI

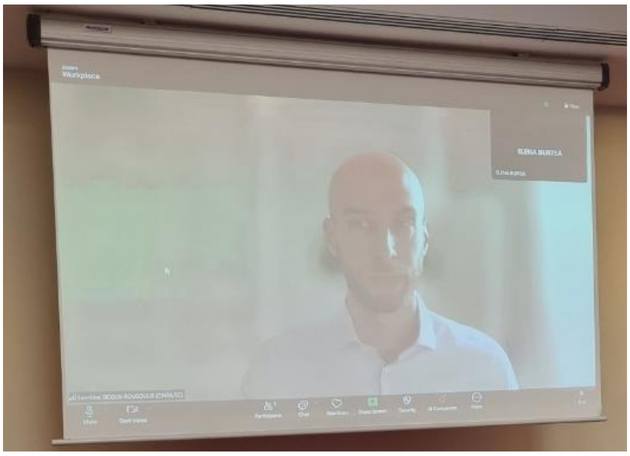
Hielke Piera	MuTech B.V., TUDelft	Cornel Tarabic	COMOTI
Friso Hartog	MuTech B.V., TUDelft	Marius Deaconu	COMOTI
Riccardo Zamponi	VKI	Laurentiu Cristea	COMOTI
Marian Fuchs	UPSTREAM CFD GMBH	Grigore Cican	UNSTPB
Roland Ewert	DLR	Cristina Covaliu	UNSTPB
Attila Nagy	BME	Mihai Predoi	UNSTPB
Michael Pott-Pollenske	DLR	Daniel Crunteanu	UNSTPB
Thomas Gianoli	CERFACS	Corneliu Stoica	INCAS
Gareth Bennett	Trinity College Dublin	Bogdan-Gruia Ivan	MCID
Alan McAlpine	ISVR	Gabriel Dediu	COMOTI
Vincent Fleury	DASSAULT-AVIATION	Silvia Gergely	MCID
Meike Jansen	DLR	Madalina Ivanciu	MCID
Jan Delfs	DLR	Mihaela Guda	MCID
Constantin Sandu	COMOTI	Dominique Collin	AVNE

1.6 Group photos

2 Introductory session

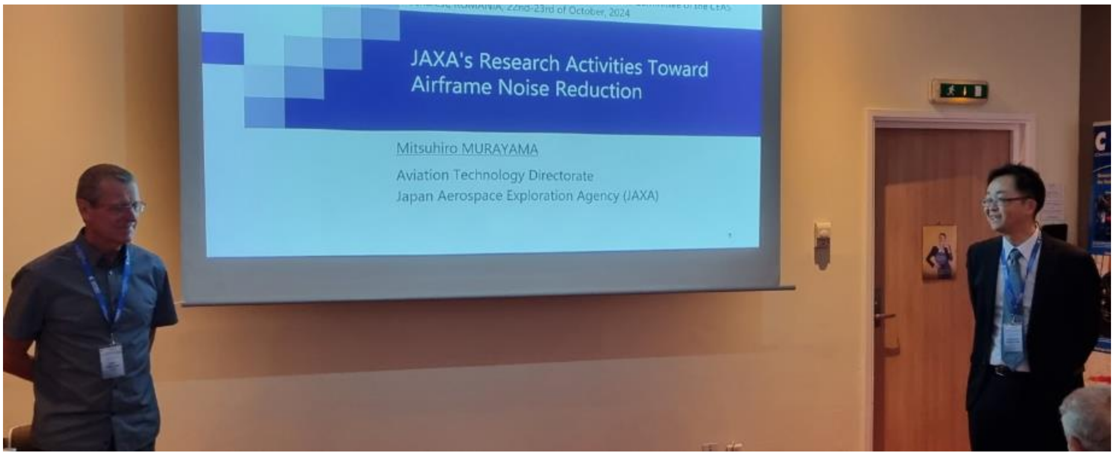
Left to right : welcome from the Ministry Of Research, Innovation And Digitalization Minister Bogdan-Gruia Ivan - Welcome to the workshop from Valentin Silivestru, President - General Manager of INCD-T COMOTI - INVENTOR Overview by Eric Manoha (ONERA), Coordinator of INVENTOR

Welcome to the workshop from Roberto Camussi (RomaTre), Chair of CEAS-ASC Committee [Online]



Keynote lecture "The contributions of INVENTOR to H2020" by Leonidas Siozos-Rousoulis, Project Officer from EC/CINEA [Online]

3 Invited Keynote Lecture



"JAXA's Research Activities Toward Airframe Noise Reduction", by Mitsuhiro Murayama (JAXA)

4 INVENTOR's contributions

4.1 Vision from the industry (A. Scotto/V. Fleury/A. Ghouali)

Needs, challenges and opportunities in the field of airframe noise

Aline Scotto (Airbus), Vincent Fleury (Dassault-Aviation) and Amine Ghouali (Safran Landing Systems)

INVENTOR is a research project launched in the HORIZON 2020 context, but it also involves partners from the main actors of the European aeronautical industry, including the two main airframers, Airbus and Dassault-Aviation, and the main landing gear manufacturer, Safran Landing System. Such industrial participation shows how critical is the need for aircraft noise reduction (airframe and engine noise) for present and future products in particular considering the lower and lower threshold noise levels allowed for certification.

This joint presentation reflects the vision from these industrial partners on the needs, challenges and opportunities in the field of airframe noise reduction. The introduction reminds the significance of reducing aircraft noise, and the contribution of airframe noise sources in certifications conditions. Then each partner presents his/her own vision on the challenges to tackle. In particular, the need for a dual experimental/simulation approach is recalled with improvements specifically expected for simulations. Indeed, computational costs may be significantly reduced by using LBM based software in order to allow optimisation through iterative simulations. DES approaches should also be improved in this direction, in particular for the generation of 3D meshes. The geometries used in simulation should also include all the details of a real airframe, at least down to 1-cm resolution (full scale). For instance, tracks, actuators and cavities have to be included in the simulations to get a good noise sources representativeness. Concerning the noise reduction technologies, industrials emphasize the need to take into account industrial constraints (such as safety, weight, aero performance, integration, maintenance, cost, CO_2 low emission ...) from the start of the concept: 0-penalty solutions are promoted and effort will be put on some low noise by design approach. Add-on technologies (such as acoustic porous fairings) show usually higher noise benefit but have significant industrial drawbacks that could be showstoppers. They can remain fix if necessary but will not be the preferred solution for a new aircraft.

4.2 LG-flap interaction (M. Fuchs)

Two numerical studies of landing gear wake / flap interaction noise

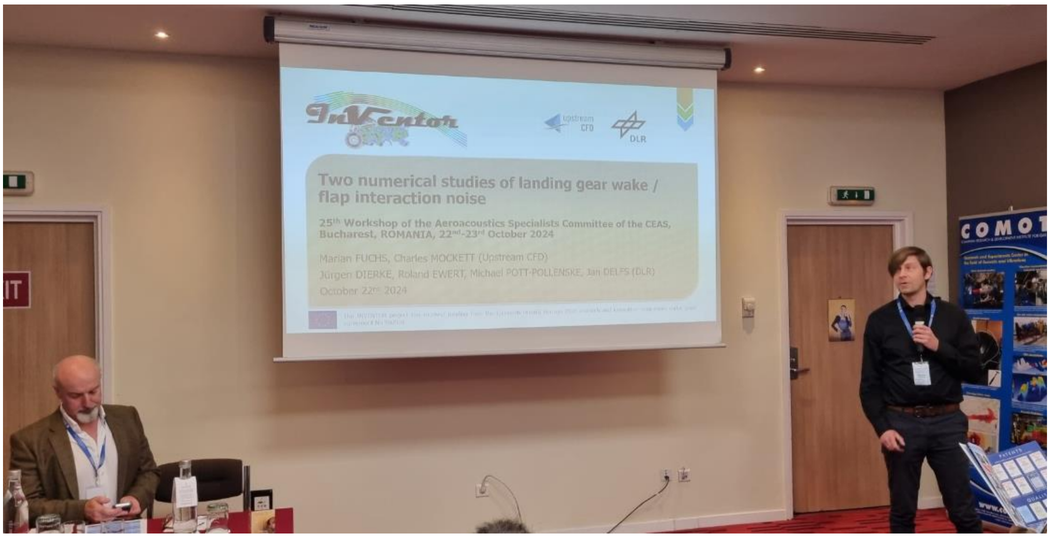
M. Fuchs*, J. Dierke§, R. Ewert§, M. Pott-Pollenske§, C. Mockett*, J.W. Delfs§

*Upstream CFD §DLR

High-lift devices and other installed components such as landing gears are known to contribute to the overall noise levels of commercial airplanes during take-off and landing. In recent years, the focus has shifted from investigating and optimising the emitted sound pressure levels of isolated components (e.g. isolated landing gear (LG) or the slat) towards studying the interactional effects that originate from the integrated environment of the high-lift wing system. In the EU project INVENTOR, two collaborative numerical studies have been conducted by the authors to investigate the noise generated by the interaction of the LG wake and the deployed flap.

Upstream CFD conducted both steady-state RANS and scale-resolving simulations (SRS) for the configuration depicted in Figure 1. The flow topology of the LG wake was investigated in more detailed to ensure that the CFD delivers an accurate representation of the turbulence impinging on the flap leading edge (FLE). This was validated by comparing the CFD results with hotwire data measured in the AWB wind tunnel of DLR. Aeroacoustics results for two configurations with different flap settings were compared, where a strong interactional noise effect of up to 5 dB could be established.

In the numerical study of DLR, CAA simulations were conducted using a stochastic forcing approach. The input mean flow field was derived from the RANS solution generated by Upstream CFD, where the generated stochastic fluctuations were confined to the wake region around the FLE. The main goal was to evaluate the noise mitigation effect of different porous inserts for the flap leading edge, which were modelled in the simulations via source terms based on Darcy-Forchheimer. For the three evaluated porous inserts, a noise level reduction of up to 5 dB relative to the solid case without insert could be demonstrated.



4.3 4-wheel vs 2-wheel MLG (L. Sanders)

<u>4-wheels landing gear noise impact assessed by LBM simulation</u>

Laurent Sanders (ONERA)

The objective of the present work is to assess the noise impact of a 4-wheels landing gear with respect to a 2-wheels landing gear. Both landing gears have been designed for the same MTOW so that the 4-wheels landing gear has smaller wheels, i.e. smaller diameters and thicknesses. In addition, a focus is made on the noise impact of the 4-wheels bogie angle variations by ± 14°. The bogie angle orientation, i.e. positive or negative, might have a significant role on the noise radiation of the wheels region. Flow and noise assessment of the landing gears configurations have been achieved thanks to the lattice-Boltzmann method (LBM) and FWH surface integrations. The work shows that (i) the 4-wheels landing gear is noisier than the 2-wheels landing gear despite its smaller wheels and (ii) the ± 14° bogie angle variations has little impact on noise even though the -14° angle is noisier than the two other ones (0°, +14°).

4.4 Scale effect on LG tests (A. Ghouali)

<u>Comparison of trailing arm main landing gear wind tunnel noise measurements at different scales</u>

A. GHOUALI (Safran LS) & V. FLEURY (Dassault Aviation)

Noise measurements on Generic Bizjet trailing arm main landing gears have been performed in the German AWB (10% scale) and French S2A (1:1 real full scale) Wind Tunnels. Both baseline and low noise configurations are tested for different speeds and using plain and porous add-on fairings. The fairings are designed to attenuate the noise generated by the sources located on the gear knuckle and between the wheels. Noise spectra at both small and full scales are compared using speed and size power standard transposition laws. Sensitivity of landing gear noise transposition to power law values is also studied and will be presented.

4.5 Flow through fairings for LG (R. Zamponi)

<u>Noise source analysis of flow-permeable fairings in the LAGOON landing gear model</u>

R. Zamponi(1,2), A. Rubio Carpio(1), F. Avallone(3), D. Ragni(1)

(1) Delft University of Technology (2) von Karman Institute for Fluid Dynamics (3) Politecnico di Torino

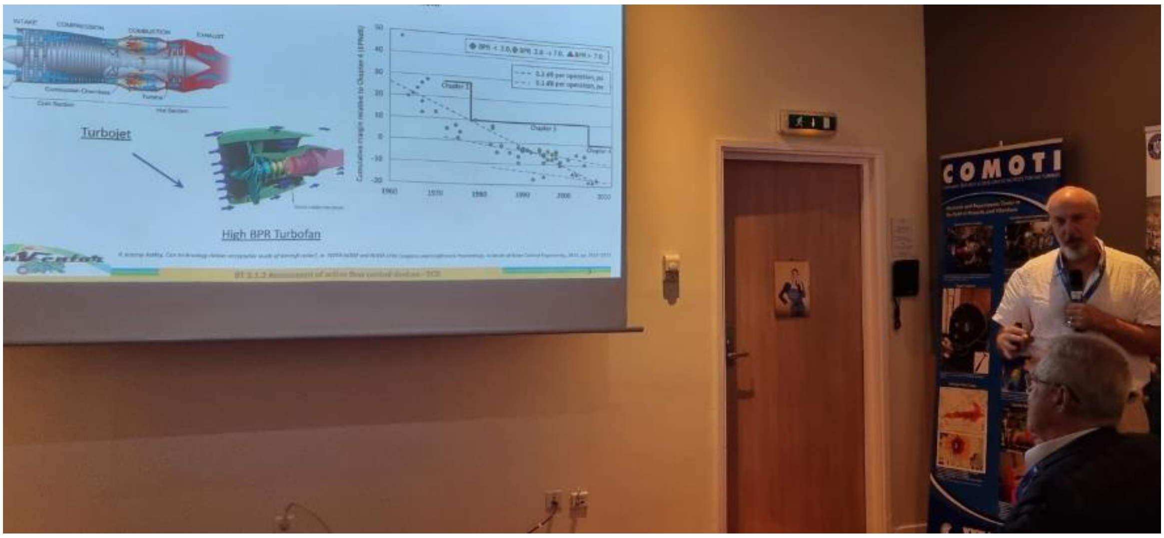
Landing gears are a major source of airframe noise in most modern commercial aircraft during approach and landing, attracting significant research focus from aeronautical engineers and aeroacoustic specialists. Solid fairings, which prevent incoming airflow from interacting with nonaerodynamic gear components, have been shown to effectively reduce noise. However, the flow deflected by these devices onto unshielded elements can create additional noise sources, limiting the overall noise-reduction potential of this technology. Porous materials have been proposed to mitigate noise while avoiding the drawbacks associated with solid surfaces. This work, which is part of the EU-funded H2020 INVENTOR project, presents an experimental investigation into the aeroacoustic and aerodynamic effects of various solid and flow-permeable fairings placed upstream of a simplified scaled landing gear model, which includes detachable components to mimic realistic noise sources. Results show that the inclusion of the torque link and brakes provides a nonnegligible contribution and modifies the location and strength of the dominant noise sources. The installation of a solid fairing covering them leads to noise reductions of up to 16 dB for both flyover and sideline directions but also a substantial increase in the blockage exerted by the model. The less permeable fairings make it possible to achieve comparable or slightly better sound attenuation than solid ones in a frequency range in which fairing self-noise, produced by the flow interacting with the pores of the material, does not dominate. In addition, flow-permeable materials decrease the model loading and the turbulence kinetic energy in its wake due to the less abrupt flow deflection, with a positive impact on the undesired noise possibly arising from the interaction with downstream uncovered gear components. The conclusions drawn in the study provide valuable insight into the design of innovative and more efficient flow-permeable fairings.

4.6 Air curtain (G. Bennett)

<u>The use of different air curtain nozzles to reduce the aerodynamic noise radiated from a modified LAGOON landing gear</u>

Gareth Bennett (Trinity University)

This paper examines the use of different air curtain nozzles to reduce the aerodynamic noise radiated from a modified LAGOON landing gear, as tested in the EU funded H2020 collaborative research project: INVENTOR, InnoVative dEsign of iNstalled airframe componenTs for aircraft nOise Reduction. At approach to landing, landing gear noise is still a significant contributor to environmental noise in the vicinity of airports. Progress is being made with ambitious projects which aim to develop significantly reconfigured aircraft architectures to reduce airframe noise. The current project examines a noise abatement concept which could be retrofit to existing landing gear configurations as an interim measure or as part of a longer-term solution. Flow control in the form of low TRL "air curtains" which form a fluidic shield or virtual fairing are examined. In order to provide a simplified baseline landing gear mock-up on which to test the low noise nozzles, the LAGOON NLG is modified with the addition of a torque-link and brakes and is called the "LAGOON-SLG". The air curtains are examined in DLRs AWB aeroacoustic facility in Braunschweig, Germany.



4.7 Slat porous inserts (M. Pott-Pollenske)

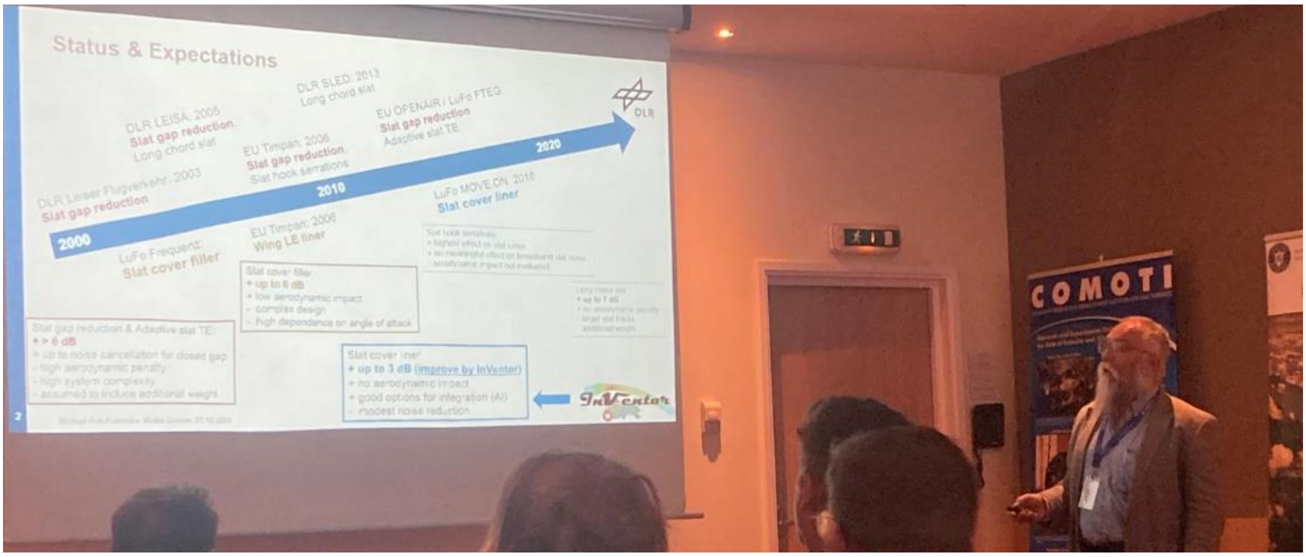
The Challenge of Slat Noise Reduction by retro-fit Technology

Michael Pott-Pollenske, Meike Jansen, Department of Technical Acoustics, Institute of Aerodynamics and Flow Technology, DLR, Germany

Within the EU co-funded research project Inventor efforts were driven to design and test so called slat cove liners based on porous material. The selected materials were off shelf open cell structures and ALM-based porous media. Acoustic tests were achieved with two basic configurations in three different wind tunnels.v

First, a noise reduction was achieved for the Bristol type inserts in all wind tunnels as shown for UoB and AWB. Second, the TE-inserts showed on the one hand noise reductions up to 3 dB but on the other hand the obtained data show contradicting results for selected test cases. Banded OASPL data as derived from the F2 measurements e.g. for the Kelvin 2 trailing edge modification (green lines / bars) showed a noise reduction in F2 but a noise increase in AWB. The latter led to the assumption that not at least installation issues may deteriorate the flow and thus diminish the achieved noise reduction.

The current work will emphasize the acoustic achievements, including the final application of porous treatments on a real 3-dimensional high lift wing as can be seen here by the comparison of sound pressure level spectra from the respective measurements in DNW-NWB. Furthermore, next steps in order to improve this technology are proposed.



4.8 HLD (slat track) noise prediction with LBM (M. Soni)

<u>Prediction of Complex High-Lift Noise and Prospects of Noise Reduction Technology using the Lattice Boltzmann Paradigm</u>

Malav Soni, Roland Ewert, Michael Pott-Pollenske and Jan Delfs (DLR).

The main emphasis of this work is on the Direct Noise Computation (DNC) of high-lift wing sections using the wall-modelled LES (WM-LES) Lattice Boltzmann Method (LBM). The research code ProLB is used as a solver here. This work builds upon our previously published work, which involved a systematic validation of the numerical DLR/ONERA F16 high-lift wing without sweep against the experimental results. This investigation augments the F16 wing's complexity by incrementally adding a sweep component and a slat-track. A simplified slat-track geometry from the predecessor projects is used. Upon comparing with the outcome of a no-slat-track case, it was verified that the presence of a track in the slat cove increases the overall noise. A local flow control in the vicinity of the track is envisaged as a measure to mitigate the additional noise. Flow control is achieved by steadily blowing bleed air at the track along different directions, i.e., streamwise (x-axis) and spanwise (z-axis), pushing away the oncoming free-stream flow to go around the track. In other words, creating an air curtain to deflect the flow away from the track. To reduce the extra turbulence generated near the shear layer's reattachment point, we investigate the effect of porosity in that region of the slat cove. In the final presentation, the effectiveness of both the active and passive noise reduction measures, namely flow control and porosity, will be discussed in detail.

4.9 Krüger slat noise (L. Sanders)

CFD/CAA Investigation of Krueger Slat Noise Reduction Based on an Existing Experimental Database

Laurent Sanders, Thomas Renaud (ONERA), Shuai Li, Shia-Hui Peng (Chalmers), Michaël Pott-Pollenske (DLR).

Krueger leading edge flaps are of high interest in high-lift devices as they comply to the requirements of laminar wing technology and are said to be quieter than state-of-the-art slat systems. This device was experimentally investigated in the German national research project INTONE led by Airbus. More specifically, aeroacoustic wind tunnel tests have been achieved at DNW/NWB on the so-called 3DFNGY semispan high-lift model of scale 1:15.5. The objective of the present work is to numerically investigate the noise benefit offered by Krueger devices with the help of Computational Fluid Dynamics (CFD) and Computational Aero-Acoustics (CAA) simulations. Two CFD approaches have been selected. The first one is a Navier-Stokes approach relying on an Improved Delayed Detached Eddy Simulation (IDDES) with the Spalart-Allmaras (S-A) model. The second one is a lattice-Boltzmann approach relying on a Wall-Model Large Eddy Simulation (WMLES). For both approaches, CAA relies on the Ffowcs-Williams and Hawkings (FWH) surface integration from collected CFD data. Three high-lift configurations have been selected from the INTONE experimental database to be addressed by CFD/CAA simulations: (i) the slat reference configuration, (ii) the Krueger reference configuration and (iii) the optimized Krueger configuration which experimentally showed a significant noise benefit. The aerodynamic and acoustic comparisons between the numerical simulation results and the measurements are finally discussed.

4.10 Spoiler noise simulation with LBM (T. Gianoli)

Numerical Investigation of Airframe Noise with the Lattice Boltzmann Method: Application to Spoiler Generated Noise

Thomas Gianoli, Jean-François Boussuge (CERFACS)

Reducing aircraft noise in current and future models poses a significant challenge for aircraft manufacturers, given the increase in air traffic and urban sprawl, along with the growing public health concerns. Aircraft noise is a combination of engine noise, significantly reduced after decades of intensive research and the use of high-bypass ratio engines, and airframe noise, primarily generated by landing gears and high-lift devices. The development of noise reduction technologies for these airframe components has been limited by the understanding of the complex flow physics mechanisms that produce airframe noise. The design of low-noise aircraft components based on multidisciplinary criteria, including acoustics, continues to be a challenge.

To reduce the approach speed of an aircraft during a steep descent, spoilers fixed to the wing can be deployed. The induced change of geometry will create noise sources that need to be characterized and reduced to comply with the increasingly strict noise standard. In this context, numerical investigations on noise generation coming from the spoiler have been performed using a novel Large-Eddy Simulation (LES) approach based on a compressible hybrid thermal Lattice Boltzmann Method (LBM) implemented within the ProLB solver. Different configurations were treated, ranging from a simplified spoiler mounted on a flat plate, to realistic High Lift Device configurations where results were evaluated and compared to experimental data.

4.11 Spoiler noise measurements (D. Angland)

Effect of a Lifting Wing on Spoiler Noise

O. Parnis and D. Angland (UoS)

This presentation investigates the noise generated by aircraft spoilers during landing as part of noise abatement procedures. Spoilers help decrease the approach velocity of the aircraft when deployed, but they can also generate noise. The outcome of this work, which was done as part of the INVENTOR project, was twofold. The first part deals with the understanding of the noise sources generated by the spoiler itself. Here, the noise generated by the deployed spoiler is analysed in isolation from the aerodynamic noise generated by other devices of the high-lift wing. The second part is to understand how these sources on the spoiler are modified when it is deployed on a high lift wing.

In this presentation, numerical simulations using a Lattice Boltzmann numerical solver are first validated with experimental data of a simple geometric case, which consists of a spoiler mounted to a flat plate. On this simple flat plate geometry, the effect of varying the spoiler deflection angle on the noise sources is determined. The changes in these acoustic sources and the flow topology when the spoiler is mounted on a lifting wing, compared to when it is mounted on a flat plate, is determined numerically. This provides an important insight into the effect of circulation on the spoiler noise and also the effect of the interaction of the spoiler with the other high-lift devices.

4.12 Slat track noise measurements/simulation (E. Manoha)

<u>Slat track noise and flow measurements in noisy aerodynamic closed section windtunnel and associated CFD/CAA computations</u>

Renaud Davy, Eric Manoha and Marc Terracol (ONERA)

The primary goals of the EU funded INVENTOR project (INnoVative dEsign of iNstalled airframe componenTs for aircraft nOise Reduction) are (i) to study the physics of the airframe noise generated by landing gear and high lift devices of transport aircraft at landing and approach, and (ii) to assess several airframe noise reduction technologies. Slat tracks, which denote the mechanical devices that allows the deployment and incidence adjustment of the leading-edge slats, are now considered as significant contributors to high lift noise, and thus are a major topic of interest in INVENTOR. The investigations are based on the assessment, via experiments and numerical simulations, of a number of generic and low noise slat track designs. Experiments have been achieved in F2, an aerodynamic wind tunnel located in ONERA-Le Fauga, with DLR's model F16, a two-dimensional airfoil (constant section in the span direction), with a 300 mm clean (retracted) chord and a sweep of 30°. The model was equipped with either a continuous (2.5D) slat or two configurations of slat side-edges, bringing more flow interactions with the slat track. Intensive aerodynamic measurements have been performed, including steady/unsteady wall pressure sensors and optical devices such as 3-component PIV and steady/unsteady 2-component LDV. Acoustic measurements were also achieved with a 120-microphone array mounted in the windtunnel ceiling. Advanced deconvoluted beamforming techniques actually allowed to isolate the noise radiated by one single slat track, despite the strong background noise and acoustic reverberation on solid walls of the test section. In parallel, among several other partners, ONERA has achieved numerical simulations of the unsteady flow around one slat track and the associated radiated noise flow. The paper presents comparisons of these computations with acoustic and aerodynamic measurements.

5 Discussion

Each technical presentation (resp. keynote lecture) was allotted a time slot of 30 minutes (resp. one hour) allowing several questions.

Apart from technical questions from the audience, mainly motivated by the need of precisions about the activities achieved in INVENTOR, the workshop was an opportunity for an interesting debate about the future of airframe noise research in Europe, and more generally about the EU answer to the question of aviation noise in a context of orienting a lot of efforts towards the decarbonation of aviation.

This debate was started by INVENTOR's Project Officer, Leonidas Siozos-Rousoulis, during his introductive talk about the place of INVENTOR in the Horizon 2020 program, starting with a short presentation of CINEA and EU strategy on aviation noise research. His slide 19 explicitly asked the following open questions, addressed to the Consortium and beyond:

- How will you maximise the exploitation of the developed tools and outputs?
- How will you continue addressing the Research and Innovation challenges of aviation noise beyond INVENTOR, also within EU-funded programmes?
- How can the EU aviation Research and Innovation community achieve wider and effective impact, towards the strive for quieter and greener aviation?

A discussion followed, with INVENTOR partners expressing worries about missing EU contexts or calls to continue their research after INVENTOR and, beyond airframe noise, the lack of noise objectives among all present (or expected) EU calls, mainly oriented to efficient propulsion and decarbonation. There is actually a risk that, at long term, this global strategy might be detrimental to the position of Europe inside the global aeronautical aeroacoustic community. This risk might be enforced by the fact that innovative technologies aiming at decarbonation are often detrimental in term of noise, which strongly justifies to maintain up-to-date skills in term of noise reduction.

On Oct 23 (Workshop Day 2), the INVENTOR's Coordinator received the following answer from Leonidas Siozos-Rousoulis:

"Many thanks again for hosting me and for giving me the chance to attend the INVENTOR workshop yesterday. I hope it has been successful so far. Regarding the questions coming from the audience on potential aeroacoustics-related topics in the upcoming Horizon Europe work programme, I would be glad to bring you and any other interested colleague in touch with our policy officers in the DGs who are responsible for the preparation of the work programme. It is very important that the voices of you, the experts, are heard by the policymakers and that aviation noise is appropriately considered in future EU-funded Research and Innovation. As such it is necessary that you extensively

communicate your EU-funded work to wider audiences (including policymakers), highlight the challenges that the aviation industry is facing in terms of addressing noise emissions, and clearly outline what you are doing to this end. I remain available to discuss further regarding any future follow-up of INVENTOR. We will also have the chance to do that at the final review meeting of course."

During the PULSAR Noise Public Workshop that was held on Oct 24-25 (same venue in Bucharest) under Eugen Kors' initiative, INVENTOR has been presented by its coordinator, and this was the opportunity to continue the debate: it was agreed that the closure of INVENTOR and ENODISE by end of this year (and DJINN last year) is the good moment to have such needs/requirements from the aeroacoustic community addressed to these policymakers.

Inside INVENTOR, our D6.6 deliverable untitled "Innovative Technology Roadmap", under the responsibility of DLR (Dissemination Manager, in the person of Michael Pott-Pollenske), might contribute to this collective effort towards tentatively orienting the EU policymakers into keeping aviation noise in the objectives of calls for 2026, which will be in preparation until March 2025.

According to the GA, this "*Innovative Technology Roadmap" should "detail the achieved results and identify the remaining research and innovation gaps to be addressed in future projects to bring to the market the developed innovations. Through this Roadmap, INVENTOR will feed further the overall strategic roadmap made by the European Aviation sector in previous CSA and RIA such as X-Noise and ANIMA. This research roadmap definition should be realized in close interaction with the PULSAR project. To this end, early exchange with the Clean Aviation JU is also recommended, to ensure alignment of roadmaps and to avoid overlaps during the roadmap definition.* ".

In this prospective, we need to summarize the future of the technologies that were addressed in INVENTOR, or what is considered as necessary and urgent in order to allow more progress through any possible actions, internal research, projects, cooperations, either already scheduled, recently submitted or just envisaged. These positions might also concern INVENTOR's technologies that we do not want to continue, or technologies not present in INVENTOR, but we consider as promising.

Our Dissemination Manager has already proposed a way forward regarding this Innovative Technology Roadmap, based on a template for a fact sheet that contains the major topics to be addressed in the deliverable, focussing on extracting global research requirements and specific needs for the addressed airframe noise contributors listed in the template.

6 Appendix: flyer

ACUVIB

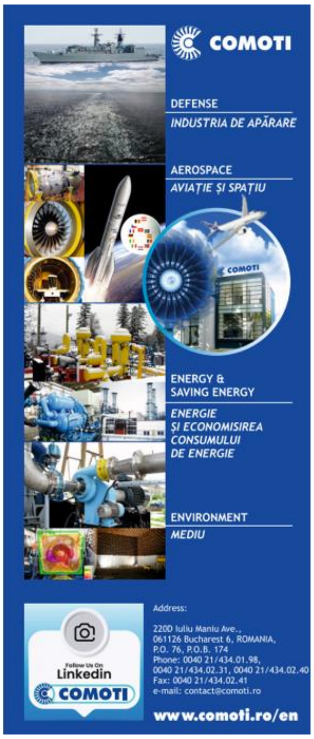
Centre of Research and Experiments in the field of Acoustics and Vibrations.

Centrul de Cercetări și Experimentări în domeniul Acusticii și Vibrațiilor.

The Romanian Research and Development Network in the fields of energy, mobility and aerospace.

ROMANIAN MINISTRY OF RESEARCH, INNOVATION AND DIGITALISATION.

If you are interested in receiving updates about the CEAS-ASC Workshop, you are kindly invited to complete the form available at: https://comoti.ro/airframe-noise-reduction/
We look forward to your participation!



AIRFRAME NOISE REDUCTION

Needs, Challenges & Opportunities

The 25th Workshop of the Aeroacoustics Specialists Committee of the CEAS, (Bucharest, ROMANIA) 22nd-23rd of October, 2024

JOINT EVENTS

InVentor PULSAR

INVENTOR and PULSAR have received funding from the European Union's Horizon Europe Research and Innovation programme under grant agreement numbers 860538 and 101095395.

SCOPE

Identifying noise pollution levels and implementing control and corrective solutions are strongly enforced at the EU level, to protect communities from noise exposure. Therefore, the assessment and management of aircraft noise is highly dependent on advancements in research and implementation of innovations in pursuit of achieving noise control and reduction.
After engine noise, **airframe noise** is regarded as being the next important noise source which influences the overall aircraft generated noise. While take-off noise is mainly dominated by engine noise, landing noise is characterised by both engine and airframe noise sources, the latter being especially dominant for the largest aircraft. Airframe noise research advancements are the key discussion topics of this workshop, given its important influence in landing noise, regarded as more important than take-off noise in characterising noise exposure levels in communities surrounding airports.

WORKSHOP TOPICS
(but not limited to)

- Low noise by design approach
- Noise reduction of High Lift Devices
- Noise reduction of Landing Gears

SCIENTIFIC COMMITTEE

Alan McAlpine (ISVR, UK)
Roberto Camussi (Roma Tre University, IT)
Denis Gely (ONERA, FR)
Eugene Kors (SAFRAN, FR)
Dominique Collin (AVNeX, FR)
Eric Manoha (ONERA, FR)
Michael Pott-Pollenske (DLR, DE)
Gareth Bennett (Trinity College Dublin, IE)
Luminita Dragasanu (COMOTI, RO)
Dan Radulescu (COMOTI, RO)
Narcisa Burtea (COMOTI, RO)

WORKSHOP INFORMATION

Key Dates

INVENTOR Final Project Meeting
21st of October, 2024
25th CEAS-ASC Workshop
22nd-23rd of October, 2024
PULSAR - Noise Roadmap Workshop
24th – 25th of October, 2024

Information about abstract submission, sending presentations and registration will be available soon on the workshop's webpage.

Location

Information available soon on the workshop's webpage.

Workshop webpage

https://comoti.ro/airframe-noise-reduction/

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Bucharest, ROMANIA
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Workshop hosted by