The 9th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2024
3 – 7 June 2024, Lisboa, Portugal

PROMISING TECHNOLOGIES TO REDUCE AVIATION NOISE AT AIRPORTS

A.CHYLA[1], M.BUKALA[1], K. KAZHAN[2], V. MAKARENKO[2], V.TOKAREV[2], O.ZAPOROZHETS[3]

[1] Noise ACH, ul. Dzielna 1/43, 00-162, Warsaw, Poland, email: andrzej.chyla@gmail.com
[2]National Aviation University, 1, Liubomyra Huzara ave., 03058, Kyiv, Ukraine, email: kazhank@gmail.com
[3]Institute of Aviation, Aleja Krakowska 110/114, 02-256, Warsaw, Poland, email: Oleksandr.Zaporozhets@ilot.lukasiewicz.gov.pl

Key words: aviation noise, reduction technologies, low noise designs, noise abatement procedures (NAPs).

Summary. With the highest priority of climate change and greenhouse gas emissions for the development of the global economy, aircraft noise is still considered a significant local impact factor around the airports. To reach the EU ACARE goals the noise reduction technologies should be developed in the same way as during previous decades for new aircraft designs so as for new low-noise operation procedures. The noise models for the reference aircraft designs are grounded for the assessment of the efficiency of noise reduction technologies. Three levels of their assessment are provided– individual aircraft flight event noise at certification points and noise footprints; airport level scenario assessment – they would be representative for the character aircraft class which includes the new aircraft design; fleet-level scenario assessment – for the strategic environmental assessment of the new aircraft designs to be implemented in air traffic.

1 INTRODUCTION

With highest priority of climate change and greenhouse gas (GHG) emissions in near future for the development of global economy the aircraft noise in/around airports is still considered as very important local impact factor. In EU the noise is a problem for over the one hundred airports because of its over-the-limit exposure on population in their vicinities and elimination of the air traffic capacity. This priority for both factors in aviation sector is realized in of a new dual ICAO standard for aircraft noise and CO_2 emission certification [1]. Balanced approach realized during last few decades by ICAO provided the huge reduction of noise exposure around the airports worldwide and first of all due to noise reduction in source guided by ICAO certification standards during last 50 years [2]. Aviation sector is expected to triple the air traffic (taking in mind only the development of usual air traffic without the contribution of the new Urban Air Mobility and other Advanced Air Mobility approaches) through 2050 and the benefits of balanced approach must not be diminished. It means that noise reduction technologies should be developed in the same way as during previous decades for new designs of aircraft so as for new their low-noise operation procedures. If to look at new supersonic aircraft future technologies are also considered in mostly traditional development of noise reduction in engines and airframes (as considered now by EU SENECA project [3, 17]).

The recent EU concept of environmentally friendly aviation by 2050 provides for the use of new technologies for aircraft designs still in operation: to reduce the perceived aircraft noise by 65% (compared to 2000) [4]. Achieving these goals requires evolutionary changes in aircraft design, improved aerodynamic configurations and the use of innovative engines [5]. The existing taxonomy of noise sources and roadmaps for their reduction should be widened to cover the new aircraft designs and technologies.

The acoustic performances of radically new innovative aircraft concepts should be in line with evolutionary achievements [6]. The electrification of aircraft propulsion and other important onboard systems [7] promises a significant reduction of aviation emissions and progress toward of strategic goals achievement. But their main noise sources like the propellers and airframe dominant sources still need for further improvements to reach the EU strategic goal in perceptive noise. The recommendation for EU EFACA project relates to the implementation of hybrid electric propulsion technology (combination a gas turbine and electric engines) for propeller-driven regional aircraft must be accompanied with appropriate noise reduction efforts [8]. Principles of aircraft hybrid electrification should be enough not only for necessary emission reduction of GHGs by regional aircraft in flight, but the goals in aircraft noise reduction should be reached [9].

An important element in the reduction of aircraft noise emissions around the airports is the use of optimal noise abatement procedures (NAPs) [10]. In combination with the planned changes in design technologies, the existing guidelines will need to be revised for NAPs.

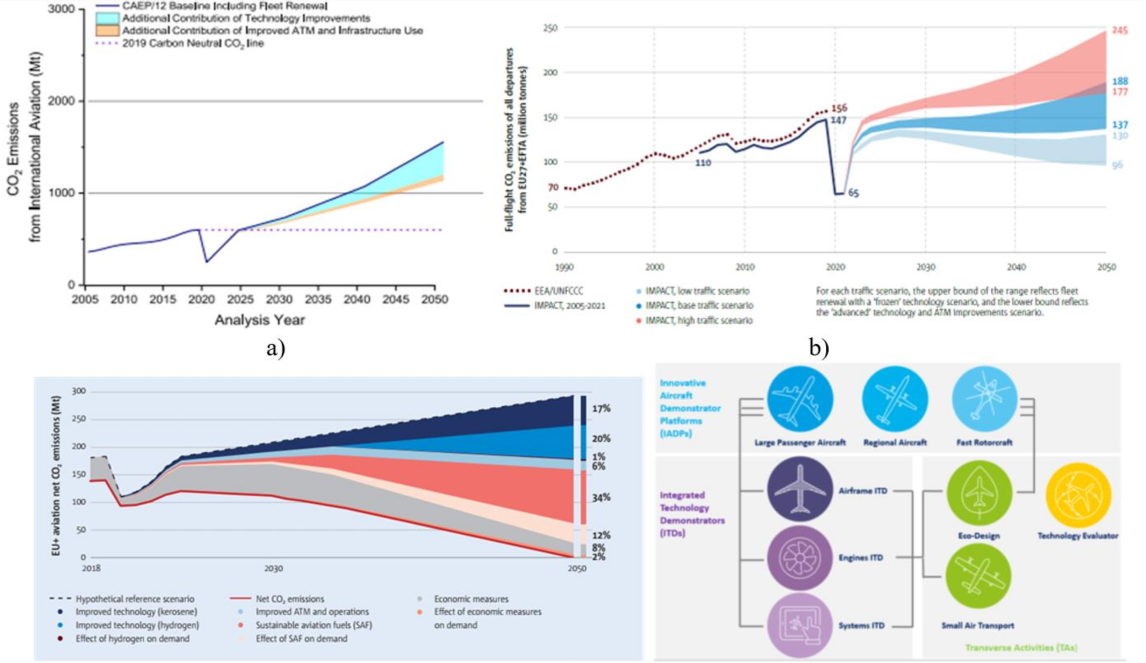
2 GLOBAL AND EUROPEAN TRENDS IN AIRCRAFT NOISE, FUEL CONSUMPTION AND ENGINE EMISSION

The continuous work on trends forecasting in aircraft noise, fuel consumption and engine emission is provided by the CAEP of the ICAO on a global level to support the decision-making process in the aviation sector worldwide (Figure 1). Complementarily to ICAO/CAEP work the EASA provides the vision of the aviation noise, global and local emissions for the European region with more specific regional peculiarities used for solving the problems of environmental protection together with other goals of aviation sector development [5]. In particular, the path to zero clean European aviation [11] proposed ways to prevent the problem of climate change through radical technological efforts in the transformation of air transport. Such roadmaps are the ground for new aircraft designs including the new disruptive technologies to reduce their environment impact.

European aviation emission (Figure 1b) was defined for the three scenarios of regional air traffic (Figure 2a) and the latest ICAO statistics show that at the end of 2023 the EU returned to the level before the COVID-19 pandemic, leading in the sectorial rehabilitation among the all specific regional divisions (Figure 2b) and showing the highest necessity in aircraft fleet transformation along the pathway described in [11]. Transformation to Clean Aviation started in several directions covering the regional aviation at the first stage with emphasize on electrification of the aircraft (hybrid electrification of the aircraft – HEA – at the beginning), usage of the liquid hydrogen (LH_2) for onboard fuel cells and for the direct combustion, together with continuous usage of the sustainable aviation fuels (SAF) of various types.

Before the COVID-19 pandemic the Regional Air Mobility (RAM) accounted for over the

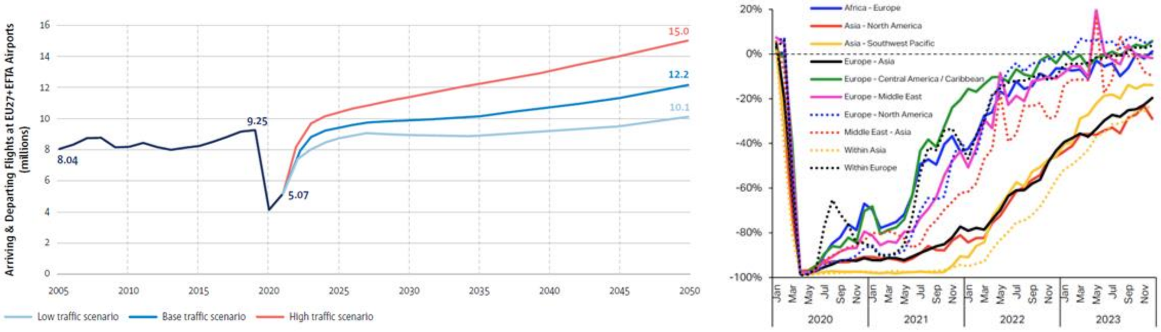
12% of world available seat kilometres (ASK), representing more than 30% of the global aircraft commercial fleet. 36% of the regional connectivity between existing airports rely exclusively on turboprop-operated services. These values are reached in huge competition with railway and road traffic, mostly beneficial around the coastal territories, where the last two meet the difficulties in providing the connections. Four megatrends were defined for Regional Air Mobility RAM and rising investment to its development: technological advances based on innovations in propulsion and aircraft design; importance of sustainability issues, which are increasingly focused by governments and the public; rising road and airport congestion; the rise of mobility as a service to public – especially in EU. These trends provided the concentration of the efforts in designing of the two types of regional aeroplanes: 80-seat, 1000-km Hybrid-Electric Propulsion Regional Airliner (HEPRA) and 150-seat, 2000 km-range Liquid Hydrogen Jet Liner (LHJL, – with a liquid hydrogen fuel system for turbine-powered propulsion). Both conceptual designs are the main TRL3 goals of the EFACA project [8].



a) b)

c) d)

Figure 1: Trends in CO_2 emission for global (a), regional overall (b), regional distributed between technologies (c) and their impact on new aircraft configurations in EU programs (d)



a) b)

Figure 2: Forecasted regional air traffic (a) and recovering of the aviation (b) after the COVID-19 pandemic

Because of currently existing huge demand on commercial supersonic air transportation (SST for both classes – business jets SSBJ and air liners SSAL) there are many different technologies being addressed, such as improving engine integration for minimizing noise, maximizing combustion efficiency, and reducing high-altitude emissions, and of course the sonic boom loudness - the boom noise should be minimized to provide the quiet and safe SST flights over the lands. The biggest challenge in the design of commercial supersonic aircraft is the trade-off between minimizing drag and thus fuel consumption during supersonic cruise while reducing noise levels in areas close to the airport. Whereas subsonic aircraft, including the regional, benefit from larger bypass ratios and consequently larger engine diameters both for cruise efficiency and landing/take-off (LTO) noise, for supersonic aircraft it is necessary to minimize the engine diameter to reduce the pressure drag for trans-sonic and supersonic speeds.

During at least 3 last decades the EU aviation manufacturers use the noise reduction technologies in aircraft designs [6], pushed by the requirements of international standards [2]. From other side of the general aircraft noise problem the ICAO noise standards requirements are grounded on the analysis of the trends and ICAO Policy goal: '*limiting or reducing the number of people significantly exposed and impacted to aircraft noise*' [12]. Currently, the specific SST noise requirements are assessed by ICAO/CAEP to be adopted internationally instead of generally for the subsonic aircraft [1], but at the current stage of SST design the subsonic Chapter 14 norms are considered to be fulfilled [13].

3 THREE GENERATIONS OF AN REDUCTION TECHNOLOGIES

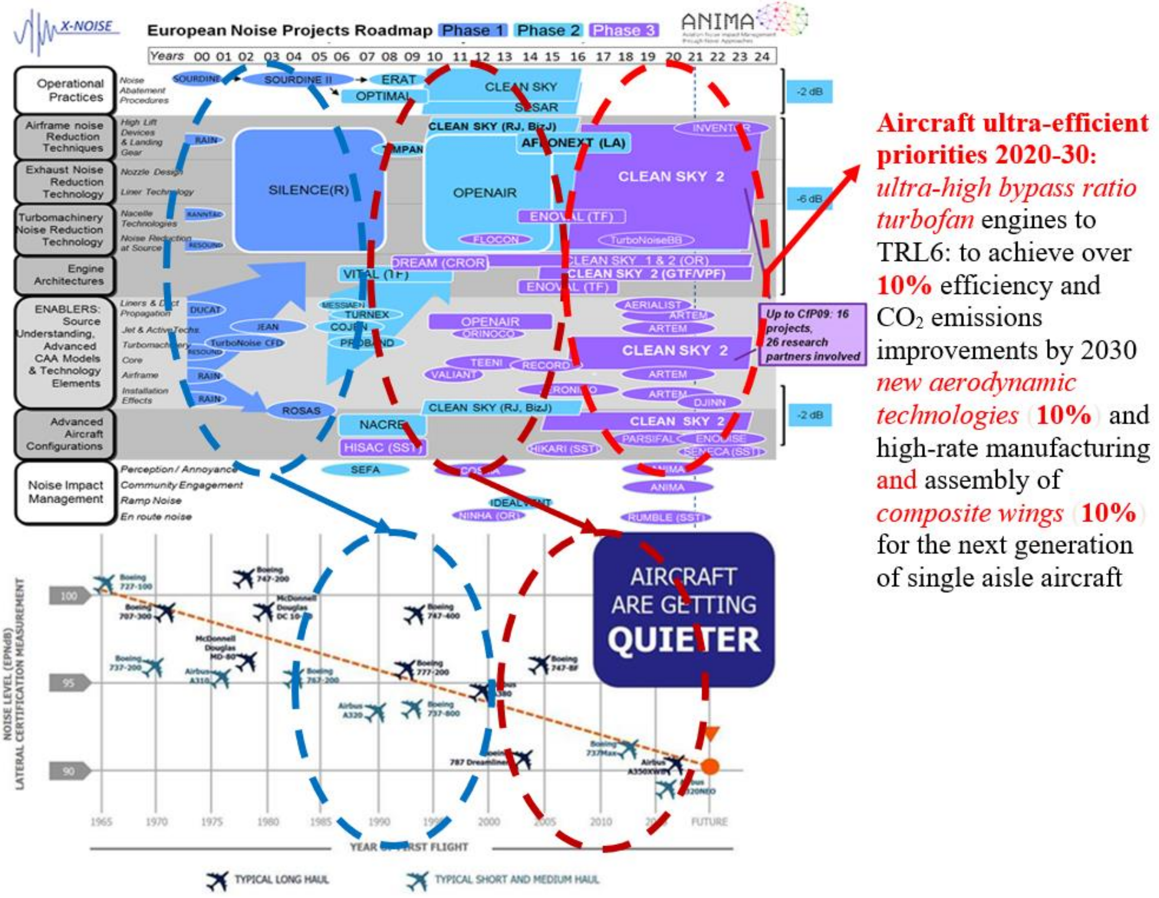
EU Silence(R) project focused on the development of Generation 1 aircraft noise reduction technologies (NRT1) [6] with over 35 tested their prototypes during the program, ten of these NRT1 were validated from the noise reduction standpoint for the Airbus-320 including the dedicated flight tests. Silence(R) established a blueprint for larger EU-funded research projects like OPENAIR and Clean Sky (Figure 3a) and dedicated Technology Evaluation process necessary for the implementation of the NRTs in new aircraft designs. And also used by XNoise and ANIMA projects to assess the progress (Figure 3b) made to this day relative to ACARE targets [4, 5]. The concept of a reference aircraft is used to constrain performance characteristics of the assumed aircraft fleet improvements (Table 1). The concept considers the state-of-the-art in commercial aircraft technologies including NRT. As such, it should reflect the performance that can be expected from new (next generation) aircraft entering service over the next decade. For the new SSAL such a reference aircraft is still the Concorde, for the business class jet – SSBJ – the reference aircraft is absent at all, but the Concorde may play this role.

Table 1: Reference type of the aeroplane in different ICAO/CAEP/IEP categories

Aeroplane category		Number of PAX seats	Reference type of the aeroplane	EU analogue
Business Jet	BJ	≤20	G650ER	Dassault Falcon 7X
Supersonic BJ	SSBJ	≤30	absent	absent
Turboprop	TP	20-85	DHC Dash 8-400	ATR 72-600
Regional Jet	RJ	20-100	E190E2	Airbus A220-300
Narrow Body	NB	101-210	A320neo	A320neo
Wide Body	WB	>210	A350-900	A350-900
SST	SSAL	100	Concorde	Concorde

3.1 Hybrid-Electric Propulsion Regional Airliner

The EFACA reference airplane for the HEPRA is an ATR-72-500/600, powered by PW127, – the most fuel-efficient regional aircraft on both a trip and a per seat basis at this sector length and 45% less operational costs at the moment. On short distances of up to around 250-300nm, the ATR-72-600 has similar emissions per seat compared to the newest generation A320Neo and 737Max aircraft. ATR-72 aircraft produces less noise than turbojets at take-off and landing, its overall noise levels are significantly below required ICAO most stringent requirements: ATR 72 is 9dB under the required standard limit. ATR 72 LTO noise footprint for the *SEL*=90dBA is 3 times less than produced by regional turbojet.



Aircraft ultra-efficient priorities 2020-30: *ultra-high bypass ratio turbofan* engines to TRL6: to achieve over **10%** efficiency and CO_2 emissions improvements by 2030 *new aerodynamic technologies* **10%** and high-rate manufacturing and assembly of *composite wings* **10%** for the next generation of single aisle aircraft

Figure 3: EU aircraft noise program roadmap (a) and noise reduction by aircraft technologies (b)

3.2 Liquid Hydrogen Jet Liner

The EFACA reference airplane for LHJL is an A320neo. Evidently, the LHJL must enter the group of RJ aircraft like A220-300 (Table 1) but the onboard LH_2 system needs a higher fuselage volume like A320. The main difference between the A320ceo and the A320neo is the new engine installed: the IAE V2500 and CFM56-5B models with by-pass ratio (BPR) ~6 were replaced with the PW1100G-JM and LEAP-1A (manufactured by Pratt and Whitney and CFM International, respectively) with BPR 12:1 and 10:1, and significantly larger fan diameter (>2 m) than their predecessors. A320neo is on 3.3% more fuel efficient that the B737Max but its full fuel efficiency ~20% in comparison with A320ceo is theoretical and can only be achieved under set conditions. The very high BPR and the latest acoustic design and technologies in propulsion system provided the noise reduction on ~4EPNdB at take-off and on ~2EPNdB at approach flight stages (Figure 3). A320neo LTO noise footprint is twice less than produced by predecessor A320ceo.

3.3 Supersonic Air Liner and Business Jet

The Concorde was the noisiest commercial airplane among all jet airplanes being in operation. It was assessed by measurements in Heathrow and Dulles [14] certification noise levels were very higher over the current ICAO standard limits (Table 2). Shown in the Table 2 noise level differences are possible to be reduced for the subsonic aircraft but still difficult for the SST because of specific requirements to engine modes and aerodynamic drag at supersonic cruise flight. Due to this specific supersonic flight performance the Concorde may be considered as a reference aircraft even for the SSBJ.

Table 2: aircraft noise certification levels (EPNdB) for the Concorde and requirements for the new SSLA

Reference point of certification	Concorde	Chapter 14	Difference
Lateral full-power	113.1	99	14.1
Approach	116.6	102.6	14
Flyover	119.3	100	19.3

3.4 CAEP IEP Technology Taxonomy

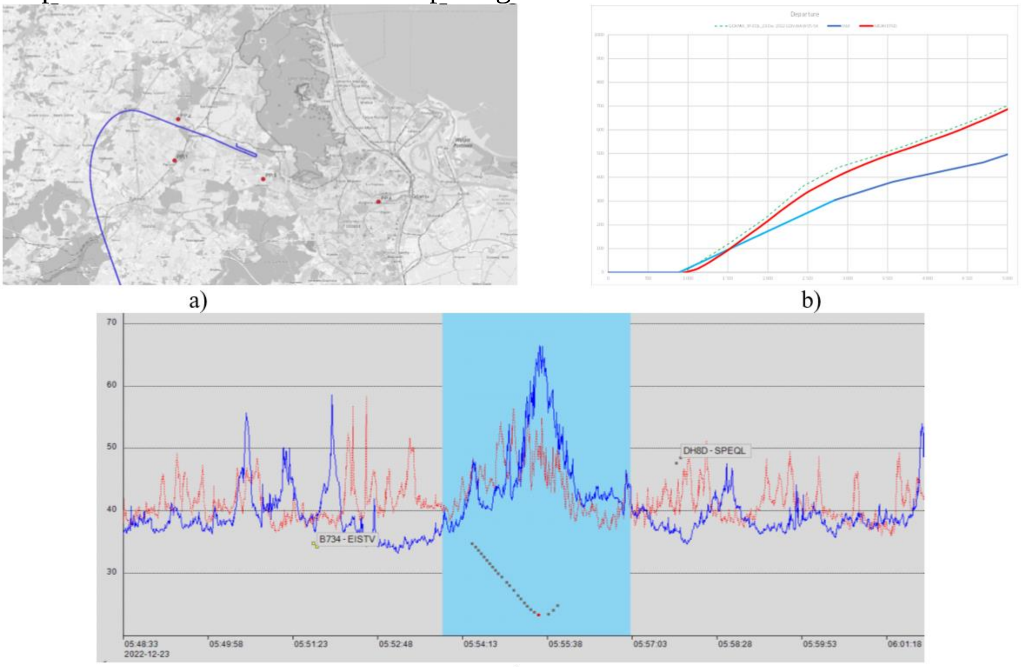
Both ICAO/CAEP IEP reports [10] emphasized on two major approaches to reducing aircraft noise for the conventional aircraft designs with conventional turbofan or turboprop propulsion: (1) advanced NRT (design features) for the different specific noise components of the airframe design, and (2) advances in propulsion system design which normally require increased BPR providing lower exhaust velocities for the turbofans and less diameters and higher number of blades for the propeller engines. Long-term efficiency of engine noise reduction due to the BPR rise (over the 10-12) is expected twice less in comparison with previous BPR values: in average -1.5 EPNdB per BPR instead of -3 EPNdB. Taking in mind the NRT achievement of the A320neo at approach – the contribution of the jet noise to overall aircraft noise at ICAO point No 3 is absent – further jet velocity reduction will not influence sufficiently the overall engine and aircraft noise. More detailed acoustic analysis will be necessary to implement for the next steps in balanced between the sources noise reduction and for the assessment of the baseline/reference aircraft model.

4 REFERENCE AIRCRAFT NOISE MODEL

4.1 ATR-72-500/600 for HEPRA reference model

Market name of the ATR-72-500/600 is an ATR 72-212A with a different set of equipment and new PW127F (or PW127M) engines with six-blade propellers (Hamilton Standard 568F). Currently the ANP data base includes the noise and performances for the ATR-72-212A with engines PW127F – definitely the model of ATR-72-500/600. They were evaluated by noise calculation and monitoring results for flight paths and sound pressure/exposure levels in spectral and temporal domains at regional Polish airports Katowice and Gdansk (Figure 4). In the ANP database ver. 3.2, the noise identifier for the ATR72 includes new spectral classes: 240 for approach and 140 for departure. Procedures from the ANP database used for modelling take-off and landing profiles by different models may exhibit certain differences in terms of flight altitude, speed, and thrust settings (Figure 5) that could lead to some temporal and spatial deviations of calculated noise contours (Figure 6) and levels at separate points (Figure 7).

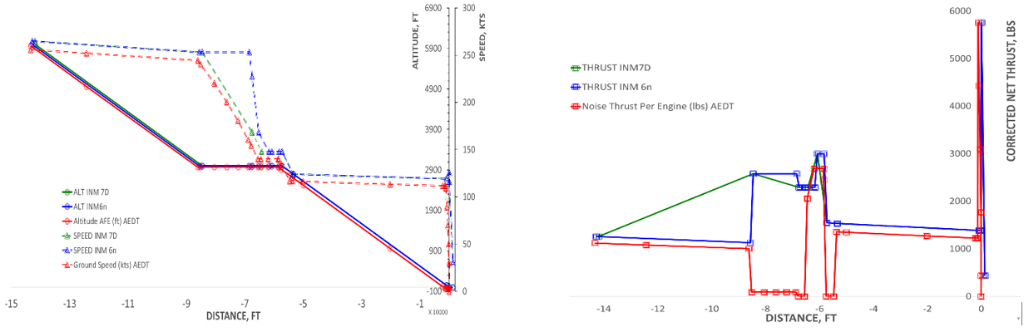
A comparative analysis of the ATR 72-212A modeling results and certification data at all three certification points are shown in Figure 7 for both departure and approach modes. Despite differences in profiles during the approach (Figure 5) and appropriate contours (Figure 6), the calculated levels at 3rd certification point 2000 m before the runway threshold (magenta points in Figure 6) are very close to the *EPNL* values in the EASA database for ATR 72-212A certification (dark blue points in Figure 7). In most cases, noise levels at the lateral 1st point for ATR-72 departure are overestimated comparing with certification data.



a) b)

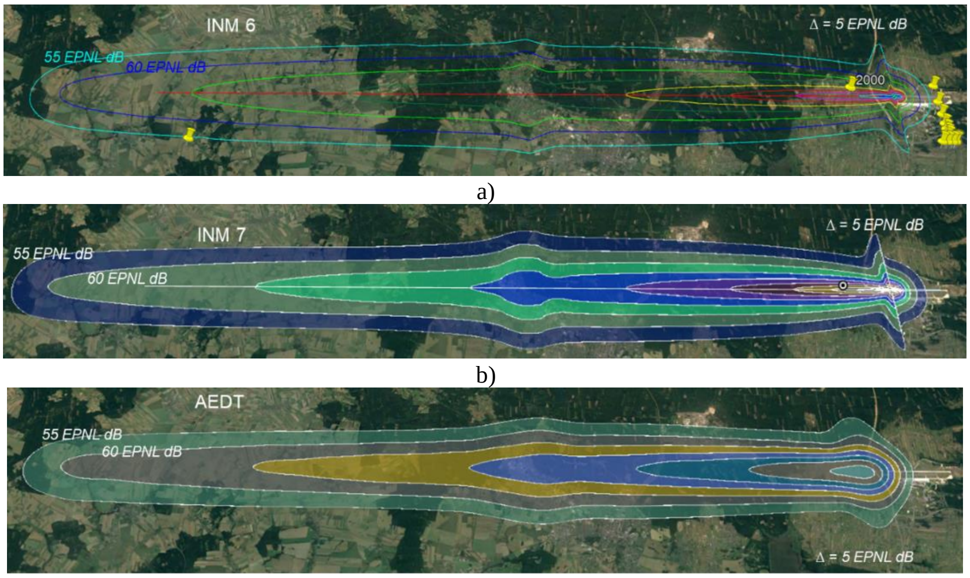
c)

Figure 4: Aircraft noise monitoring terminals in Gdansk airport (a) and ATR-72 departure flight path (b) and $L_A(t)$ dependence at noise measurement point



a) b)

Figure 5. ATR-72-212A approach profiles for generic airport in terms of altitude and speed (a) and corrected net thrust (b) provided by models: INM 6.0 (blue), INM 7.0d (green) and AEDT 3d (red).



a)

b)

c)

Figure 6. *EPNL* noise contours for single approach modelled with a) INM 6.0: b) INM 7.0d and c) AEDT 3d

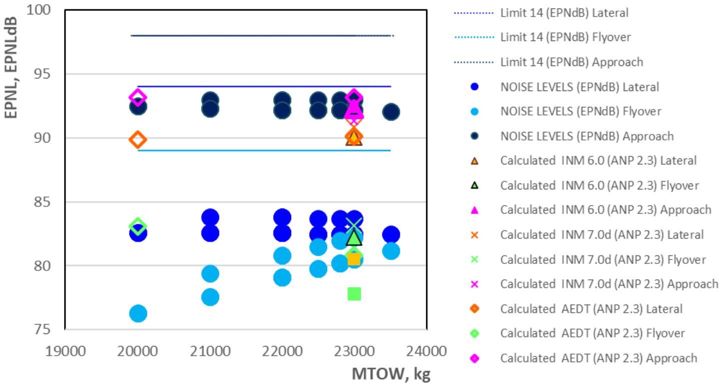
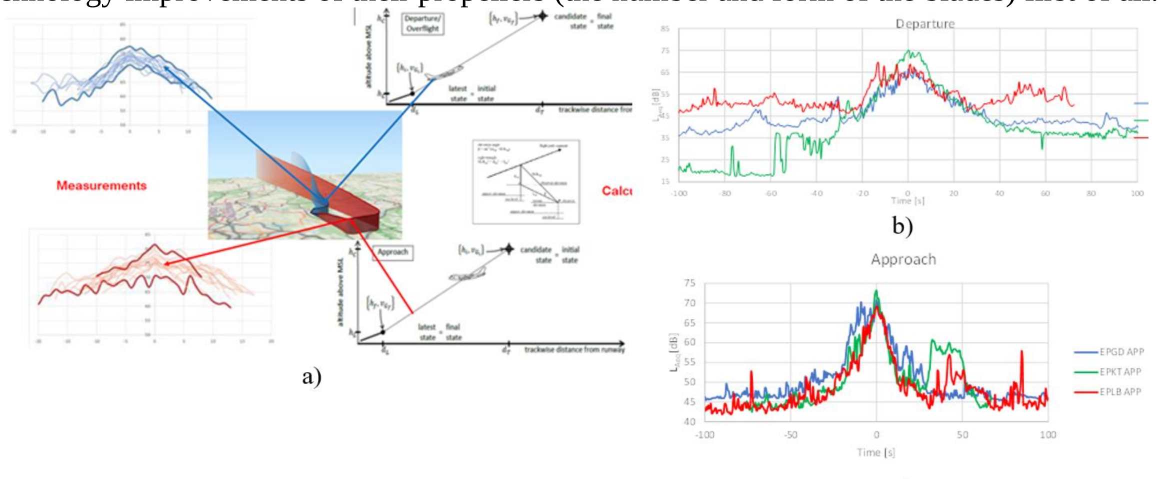


Figure 7. Comparison of modeling with certification noise data for the ATR-72-212A with different MTOW and engines (source: EASA Certification Noise Levels. Heavy propeller driven aeroplanes noise database)

To be able to assess the impact of any available NRT or the change of the engine type, based on the time history of the recorded acoustic signal, third-octave spectra of the sound pressure level at the moment of the maximum sound level were determined, characteristic to the aircraft under consideration (Figure 8). Noise monitoring results from Katowice and Gdansk airports (Figure 4) were used for comparison with INM/AEDT calculations for *SEL* and L_{Amax} (Figure 8b,c) and their spectra at the moment of $L_{\mathrm{A}}(t)=L_{\mathrm{Amax}}$ (Figure 8a) with calculations by NoiTra model (Figure 9). Average values of the exposure sound level and average noise spectra were determined separately for departures (Figure 8b) and arrivals (Figure 8c) over a representative recorded time period. The carried-out analysis took into account multiple flights of the aircraft over the measurement point, which allowed for the determination of extreme values, and the average values of noise emission as a function of time allow to present reliable results of the average third octave spectrum of the sound pressure level.

The spectral results were compared with the same for the Dash-8-400 measured at Manchester airport and calculated by FLIGHT model [15] – they show good agreement between the aircraft of the same class/group. The contribution of the propeller noise is dominant for these aircraft, their further overall noise reduction depends on the new aerodynamic noise technology improvements of their propellers (the number and form of the blades) first of all.

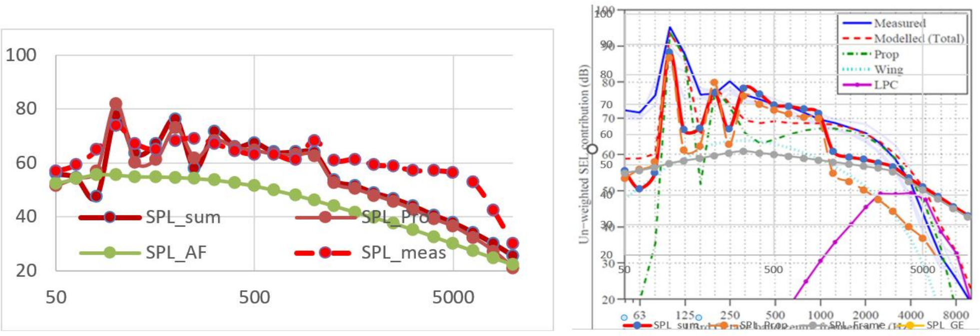


a)

b)

c)

Figure 8: Aircraft noise monitoring terminals in Gdansk airport (a) and ATR-72 departure flight path (b) and $L_A(t)$ dependences at noise measurement point



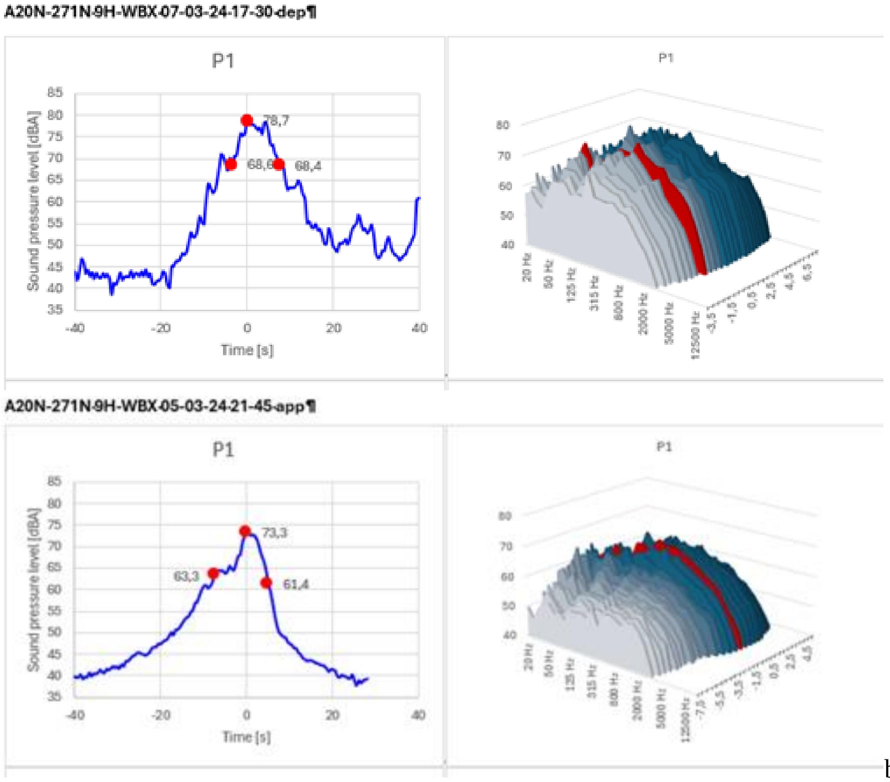
a) b)

Figure 9: Aircraft approach noise spectra for ATR-72 (a) and Dash-8: calculated spectra by NoiTra model; measured spectra by monitoring stations at airports

Noise model of the ATR-72-500 in EFACA project must consider the contribution of the airframe (flaps and landing gear) noise sources also because their contribution will be important especially after the reduction of propeller noise contribution. For the grounding of the blades' form with less generated noise the computational aeroacoustics codes [16] will be used. Their results will improve the propeller noise model for new blades designs and the aircraft noise data in ANP data base to be used for the HEPRA in future aircraft, airport and fleet scenario.

4.2 A320neo for LHJL reference model

Similar approach was implemented for reference modelling of the LHJL aircraft. The data for A-320neo were included in airport noise modelling from EASA ANP database v6.2. Based on the measured values at 10 monitoring points in Polish airports (Figure 10), a comparison was made with calculated values for exposure sound level L_{AE} and spectra of the A-320neo and A-320ceo. Significant differences between the monitored A-320neo and A-320ceo exposure levels were obtained: [1.8…5.6] dBA at take-off and [0.5…3.7] dBA at approach flight stages. All of them are covering their noise certification differences shown in 3.2. Dominance of the fan noise is evident for this aircraft type, further rise of the engine BPR will not change this trend. For overall noise reduction of the future LHJL aircraft the balanced approach of NTR implementation for the engine fan and core noise and airframe noise should be efficient.



a)

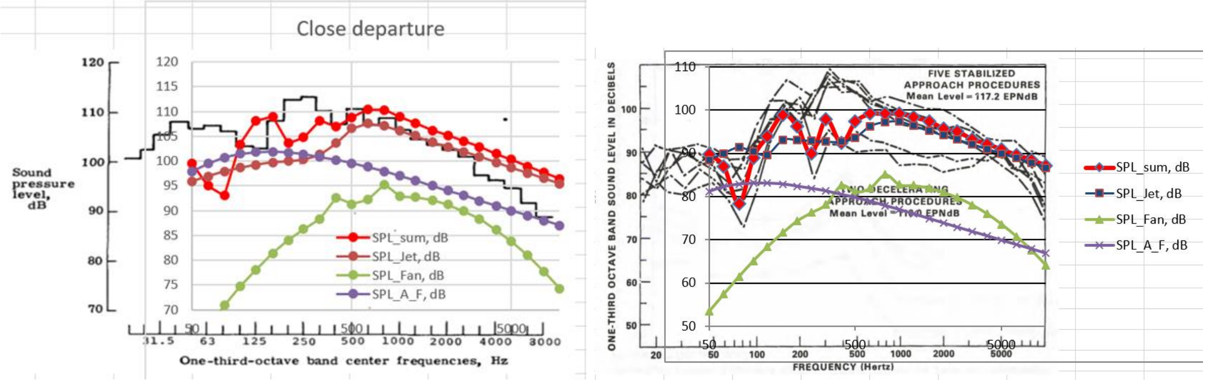
b)

Figure 10: Aircraft departure (a) and arrival (b) noise levels and spectra for A-320neo

4.3 Concorde for SSAL and SSBJ reference model

ANP data base includes the data for Concorde, but it is absent in operation at the moment and its noise monitoring results was used from the monitoring program realized during the EIA campaign in 1970s [14]. The spectral modelling at approach and climbing noise are in good accordance with their measurements (Figure 11), so as the certification levels defined from these measurements and current modelling calculations - Table 3. The calculations were provided for two different cases: without the effects – for the stable engine mode and its balanced thrust for the considered flight stage (for example a maximum at point No1); with the effects – for unstable engine mode at approach to control the flight velocity over safe limit V_2 (at point No3), cut-off thrust during the climbing over the point No 2 and included twin-jet effect in modelling the noise level at sideline point No 1.

Jet noise contribution is much more dominant for the Concorde noise, its reduction is the first step of the overall reduction of the new SSAL and SSBJ noise at certification points. But because of the very similar airframe designs the installation effect for new SSAL and SSBJ are expected the same as observed for Concorde. It must include the twin-jet effect for the sideline point and reflection from the wing of the fan exit noise at points under the flight paths.



a) b)

Figure 11: Concorde noise spectra at departure (a) and approach (b) in Dulles International Airport

Table 3: Aircraft noise certification levels (EPNdB) for the Concorde and requirements for the new SSLA

Aircraft Type	Noise Level, EPNdB		
	Take-off No1	Departure No2	Arrival No3
Concorde measured	113.1	119.3	116.6
Concorde calculated			
without the effects	117.7	121	105.1
with the effects	112.8	115	116.3

For the new by-pass engines the noise contribution from the fans will be equalized with jet noise thus their installation effect is expected essential to overall noise at certification points under the flight paths (Table 4). Acoustic liners for the fan noise reduction with quite big efficiency is possible to be used to fulfil the ICAO Chapter 14 [13] certification noise requirements (Table 1) as it was shown by SENECA project [17]. A programmed thrust lapse rate (PLR) at take-off may help solving this task if a fully automatic FADEC (Full Authority Digital Engine Control) controlled thrust reduction will be considered for new certification procedures which may provide a variable noise reduction system where noise is abated automatically without flight crew intervention [17, 18].

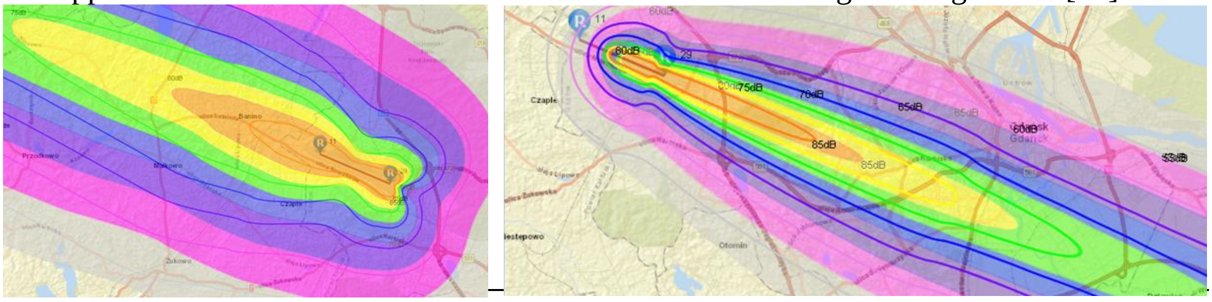
Table 4: Aircraft noise certification levels (EPNdB) for the the new SSLA

Aircraft Type	Noise Level, EPNdB		
	Take-off No1	Climbing No2	Approach No3
Minimum	103.86	103.61	101.58
Maximum	103.94	103.61	103.23
Acoustic liners for the fan noise reduction	88.74	88.43	94.17
Certification	99	100	102.57

5 AIRCRAFT TYPE AND AIRPORT/FLEET SCENARIOS

In both EU projects – SENECA in Horizon-2020 and EFACA in Horizon-Europe – the approach of the baseline/reference aircraft noise modelling is used to show efficiency of technologies realized for them and the efficiency of perspective noise reduction technologies to be realized for the new aircraft in design. Aircraft noise modelling is used in three prediction options: spectral, temporal, and area domains. Semi-empirical noise source models included in NoiTra soft tool [19] provide third-octave frequency bands for each emission angle based on parameters that are already available within the conceptual aircraft design phase. NoiTra tool is similar with aircraft noise calculation tools from NASA, DLR and ONERA [20] for noise predictions and their uncertainties associated with the simulation. NoiTra may simulate both general strategies to mitigate aircraft noise exposure: modification of the aircraft design, emphasizing on noise reduction in sources, and modification of the flight procedure, reducing the noise by flight optimization. Spectral analysis at the point L_{Amax} for SEL or/and $PNLT_{Max}$ for the $EPNL$ assessment evidently show the contribution of the dominant noise sources which are subject for noise reduction by implementing new NRT first of all.

Exposure levels in temporal domain are used for the certification purposes and are efficient for comparison of the design and/or operational alternatives realized relatively to the baseline aircraft. Also effective the comparison between the LTO noise footprints (usually for the level close to the Standard limit [13]) of the baseline aircraft with alternative design or operational flight procedure. The LTO noise footprints for the A-320neo and A-320ceo are compared in Figure 12. Further noise reduction will be achieved in future engines by reducing the length of their nacelle; by shortening the air inlet duct; improved acoustic liners; more efficient installation of the engines shielding their noise, etc. NRTs are included in the simulation as source-specific attenuations that were assessed in dependence to engine and airframe design and applied to the sound level calculation in accordance to the flight configuration [19].



a) b)

Figure 12: A-320neo noise footprints (shown by lines) are twice less than for A-320ceo (shown by coloured areas) and close to Gdansk airport dimensions: a) departure; b) arrival

The exposure levels and footprint calculations are usually use for comparing the noise emission of individual aircraft. The framework developed in [19] and quite similar in [22] can be used for generating noise-power-distance data for aircraft designs with realized NRT, which then can be used by airport and fleet noise modelling. The principles for airport and fleet level scenarios are still in development in EFACA and SENECA projects to show the efficiency of new aeroplanes implementation in air traffic globally. For them the equivalent noise levels (L_{Aeq}) and noise indices (L_{DEN}) are subject of assessment for the quiet complex air traffic at the airport. The concept of representative in-class is useful for simplification of the analysis at airport scenario especially considering the strategic fleet-level assessment [21, 23]. For fleet noise assessment of the new NRT are dependent of fleet composition and quantification of noise energy of the included in consideration aircraft classes in comparison with representative in-class aircraft – the reference aircraft of the studies. In both case – airport and fleet scenarios – all the benefits in terms of noise exposure might be assessed by changes in noise contour areas.

6 CONCLUSIONS

The noise models for the reference designs of the main aircraft groups are grounded for the consideration of the efficiency of noise reduction technologies in EFACA and SENECA projects under the umbrella of the EU Horizon program. The approach is very similar to CleanSky 2 Technology Evaluator, it is accompanied with measured data from noise monitoring of the reference aircraft in real operation in airports and soft tools designed in the Kyiv National Aviation University – IsoBella for the LTO and airport noise scenario assessments and NoiTra for the flight path noise assessment. NoiTra calculation tool is comparable with similar tools from NASA, DLR and ONERA [20], providing the possibility for any new NRT assessment for the new aircraft/engine designs. NRT Taxonomy, proposed by ICAO/CAEP [10], is used at EFACA Aircraft Noise Evaluator and still in improvement in both projects concerning the circumstances of elaborated aircraft designs. Three levels of the assessment are provided at EFACA and SENECA projects – individual aircraft flight event noise at certification points and noise footprints; airport level scenario assessment – it should be representative of the character aircraft class which includes the new aircraft design; fleet level scenario assessment – for the strategic environmental assessment of the new aircraft designs to be implemented in air traffic.

Acknowledgement: Acknowledgement to EC Horizon EFACA project No 101056866 “Environmentally Friendly Aviation for all Classes of Aircraft” and SENECA project № 101006742 “((LTO) noiSe and EmissioNs of supErsoniC Aircraft) “

REFERENCES

[1] Owen, B., and Iovinelli, R. 2022. “The Next Logical Step: Integrated ICAO Environmental Standards”. In *ICAO Environmental Report 2022*: 113- 115. https://www.icao.int/environmental-protection/Pages/envrep2022.aspx

2. ICAO Secretariat, 2019. 50 years of Annex 16 – the Special Meeting on Aircraft Noise in the Vicinity of Airports. ICAO Environmental Report 2019, p. 39-43.
3. Villena Munoz, C.; Bonavolontà, G.; Lawson, C.; Riaz, A.: Conceptual Design of a Next Generation Supersonic Airliner for Low Noise and Emissions. AIAA SCITECH 2023. https://doi.org/10.2514/6.2023-0215.c1
4. ACARE, 2011. FlightPath 2050, Europe’s Vision for Aviation. Report of the High Level Group on Aviation Research, https://www.arcs.aero/sites/default/files/downloads/Bericht_Flightpath_2050.pdf
5. ACARE 2020.Time for change. The need to rethink Europe’s FlightPath 2050 https://www.acare4europe.org/wp-content/uploads/2022/02/Time_for_change_FlightPath_2050.pdf
6. Kors E., Collin D. Perspective on 25 Years of European Aircraft Noise Reduction Technology Efforts and Shift Towards Global Research Aimed at Quieter Air Transport. In book: Aviation Noise Impact Management. Technologies, Regulations, and Societal Well-being in Europe. Editors: Leylekian L., Covrig A., Maximova A. https://link.springer.com/book/10.1007/978-3-030-91194-2
7. Zaporozhets et al., 2020 O. Zaporozhets, V. Isaienko, K. Synylo. Trends on current and forecasted aircraft hybrid electric architectures and their impact on environment. Energy,

211 (2020), Article 118814, 10.1016/j.energy.2020.118814

8. Campos L. B., Marques J.G. Serrão P.A., 2024. The EFACA Project – Environmentally Friendly Aviation. Green and Digital Technologies for Climate, Energy and Transport Challenges Special Technology Sessions – Book of Abstract. ECCOMAS Congress 2024, 3 – 7 June, Lisbon, Portugal. – p.72.
9. Kazhan K et al., 2023. Noise Assessment Scenarios for New Airplane Climate Efficient Designs. ISEAS'23 Abstract Book, SS13, p. 31. https://2023.iseas.org/abstract-book/
10. ICAO Doc 10177, 2023. Manual on Operational Opportunities to Reduce Aircraft Noise, 1st Edition, 2023 https://store.icao.int/en/manual-on-operational-opportunities-to-reduce-aircraft-noise-doc-10177
11. Destination 2050. A Route To Net Zero European Aviation. NLR-CR-2020-510, 2021 https://www.destination2050.eu/wp-ontent/uploads/2021/03/Destination2050_Report.pdf
12. ICAO Resolution A41-21 (2022) Consolidated statement of continuing ICAO policies and practices related to environmental protection – general provisions, noise and local air quality ICAO resolutions adopted by the assembly, Provisional edition, Oct 2022. – 176 p.
13. ICAO Annex 16 to the Convention on International Civil Aviation — Environmental Protection: Volume I — Aircraft Noise, 2019.
14. Tanner C.S. Noise measurement of Concorde 02 approach and take-off at Dallas-Ft.Worth and Dulles International Airports. US EPA, Report 550/9-74-013, 1974
15. Hughes R., Filippone A. Fly Over Noise Measurements and Simulation for a Turboprop Aircraft. Inter-Noise 2013, Innsbruck, Austria, 15-18 Sept. 2013.
16. Klimczyk W., Sieradzki A., Kekus-Kumor P. Prediction of airfoil tonal noise using URANS computations and its mitigation. Aerospace Europe Conference 2021 will be held in Warsaw, 23-26 November 2021. https://psaa.meil.pw.edu.pl/AEC2021/Papers/AEC_2021_141_Klimczyk_Witold.pdf
17. Gräbert M. et all. Landing and takeoff noise prediction of conceptual supersonic aircraft. ICAS-2024, Florence, Italy, 2024.
18. M. Nöding, M. Schuermann, L. Bertsch, M. Koch, M. Plohr, R. Jaron, and J. J. Berton. Simulation of landing and take-off noise for supersonic transport aircraft at a conceptual design fidelity level. Aerospace, 9(1):9, 2022.
19. Zaporozhets O., Levchenko L. Accuracy of Noise-Power-Distance Definition on Results of Single Aircraft Noise Event Calculation. Aerospace 2021, 8(5), 121; https://doi.org/10.3390/aerospace8050121
20. Sanders L., et all. The Aircraft Noise Simulation Working Group (ANSWr) – V2 Aircraft Results. AIAA 2019-2540, https://doi.org/10.2514/6.2019-2540
21. Torija A.J., Self R., Flindell I.H. Airport noise modelling for strategic environmental impact assessment of aviation. Applied Acoustics 132 DOI:10.1016/j.apacoust.2017.10.017
22. Synodinos A., Self R., Torija A.J. Framework for Predicting Noise–Power–Distance Curves for Novel Aircraft Designs. Journal of Aircraft 55(9), DOI: 10.2514/1.C034466
23. Bernardo J., Zaidi T.A., LeVine M.J., Jimenez H., Mavris D. A Rapid Integrated Interdependent Fleet-Level Environmental Model. Journal of Aircraft, 2017, DOI:10.2514/1.C033572