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CLAIRPORT – Environmental impact assessments at airport level in Clean Sky 2 TE

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Abstract

Building on the first Clean Sky Programme, the Clean Sky 2 Programme aims to make a substantial contribution to the ACARE 2050 environmental goals by accelerating the introduction of new aircraft technology in the timeframe 2025-2035. Cross-positioned within this programme, the Technology Evaluator is a dedicated evaluation platform with the key role of assessing the environmental impact of technologies developed in Clean Sky 2 and their level of success towards these ACARE environmental goals. It conducts assessments at three complementary levels: aircraft, airport, and air-transport system level. This paper addresses the environmental-impact assessment at airport level for fixed-wing aircraft, as performed in the CLAIRPORT project.

Keywords: Clean Sky 2 TE, environmental-impact assessment, airport level

1. Introduction

The Clean Sky 2 Joint Undertaking was established by Council Regulation (EU) No 558/2014 of May 6, 2014, to develop cleaner air transport technologies for earliest possible deployment, and in particular the integration, demonstration and validation of technologies capable of:

- Increasing aircraft fuel efficiency, thus reducing CO_2 emissions by 20 to 30% compared to 'state-of-the-art' aircraft entering into service as from 2014;
- Reducing aircraft NO_X and noise emissions by 20 to 30% compared to 'state-of-the-art' aircraft entering into service as from 2014.

Besides improving the environmental impact of aeronautical technologies, the objective of Clean Sky 2 is also to develop a strong and globally competitive aeronautical industry and supply chain in Europe.

The Clean Sky 2 Programme structure is depicted in Figure 1. Aircraft technologies are developed in three different elements:

- Innovative Aircraft Demonstrator Platforms (IADPs: Large Passenger Aircraft, Regional Aircraft, and Fast Rotorcraft);
- Integrated Technology Demonstrators (ITDs: Airframe, Engines, and Systems);
- Transverse Activities (TAs: Small Air Transport and Eco-Design).

The key demonstrators are shown in Figure 2.

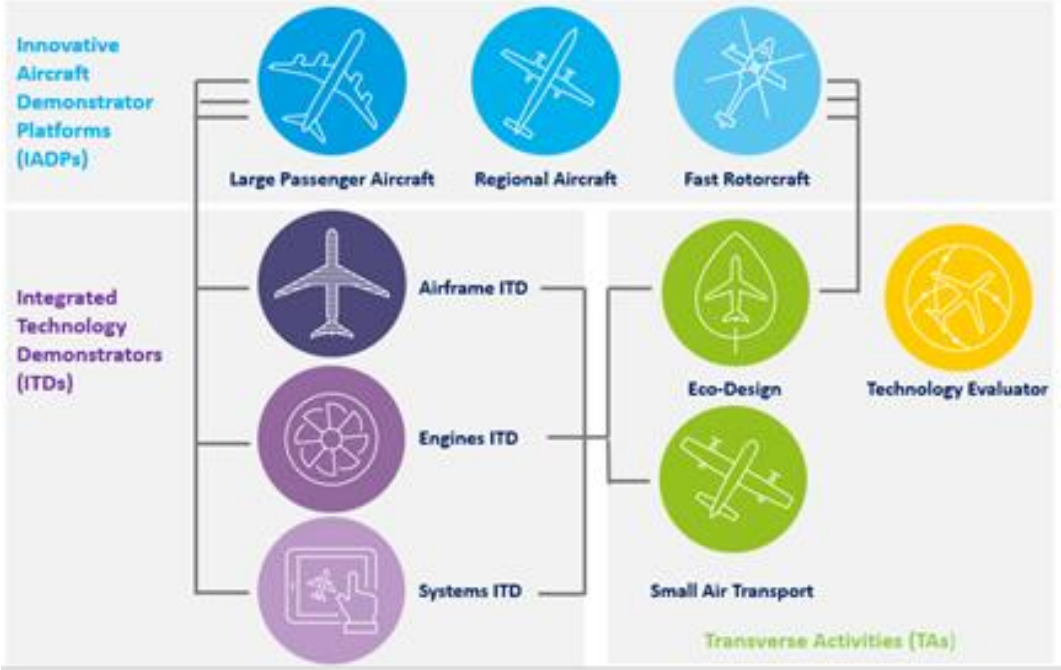

Figure 1 – Structure of Clean Sky 2 Programme [www.cleansky.eu]

Figure 2 – Clean Sky 2 key demonstrators [www.cleansky.eu]

In addition to the three elements in which Clean Sky 2 technologies are developed, the Technology Evaluator (TE), as a Transverse Activity, has been established as an independent technology evaluator for the entire duration of the Clean Sky 2 Joint Undertaking. Its main task (as per Council Regulation (EU) No 558/2014) is to monitor and assess the environmental and societal impact of the technological results arising from individual ITDs and IADPs across all Clean Sky 2 activities, specifically quantifying the expected improvements on the overall noise, greenhouse gas and air pollutants emissions from the aviation sector in future scenarios in comparison to baseline scenarios.

Clean Sky 2 technologies are clustered by IADPs, ITDs and TAs in coherent and mutually compatible solution sets, defining Clean Sky 2 concept aircraft. Clean Sky 2 TE conducts assessments on these various concept aircraft at three complementary levels:

- Aircraft level: Clean Sky 2 concept aircraft are compared with their reference-technology counterpart on relevant missions regarding emissions and noise. The results are the basis to quantify the success level versus the Clean Sky 2 environmental goals.
- Airport level: The environmental performance for a typical day at representative European airports is compared for a fleet with and without Clean Sky 2 concept aircraft, and analysed regarding noise and emissions.
- Air Transport System level: The environmental performance for a year with all global flights is compared for a fleet with and without Clean Sky 2 concept aircraft, and analysed regarding emissions and noise.

The Clean Sky 2 TE project 'Clean Sky 2 – Airport Environmental Impact Assessments for Fixed-wing Aircraft' (CLAIRPORT) quantified the environmental impact at airport level of technologies developed in Clean Sky 2 for fixed-wing aircraft. It provided the airport-level contribution to the Clean Sky 2 First Global Assessment (as laid down in the public documents [2] and [3]). The CLAIRPORT consortium is comprised of a single organisation: Stichting Koninklijk Nederlands Lucht- en Ruimtevaartcentrum NLR (Royal Netherlands Aerospace Centre).

This paper provides an overview of the CLAIRPORT's assessment approach and the results emerging from its assessment.

2. Airport-level assessment: Approach

The objective of CLAIRPORT is to assess the environmental impacts at airport level of the technologies developed in the Clean Sky 2 Programme for fixed-wing aircraft by realistically addressing aircraft movements in the local airspace of airports. This assessment is carried out for timeframes 2035 and 2050 for a representative set of European airports and for a generic airport. It focuses on the quantification of the reduction in noise, CO_2 and NO_X emissions.

For a given timeframe and airport, the basic assessment principle is to compare the environmental performance of two aircraft-traffic scenarios. The first scenario is a one-day flight schedule with Clean Sky 2 reference-technology aircraft in the relevant classes (long-range, short-/medium-range, and regional). The second scenario uses the same flight schedule, but in which (based on fleet replacement rates) Clean Sky 2 concept aircraft replace their reference-technology counterparts to evaluate the potential of the environmental benefits of Clean Sky 2 technologies for fixed-wing aircraft. The assessment approach is elaborated in the next subsections, noting only Clean Sky 2 concept aircraft defined by IADPs Large Passenger Aircraft (LPA) and Regional Aircraft (REG) are considered in CLAIRPORT.

2.1 Airport selection

CLAIRPORT conducts environmental-impact assessments for a representative set of European airports and a generic airport. For this purpose, various types of airports are considered to cover a broad range of airports and to deliver sufficient representative information on environmental impacts of Clean Sky 2 technologies at airport level.

The airports are selected through a two-step approach:

- Categorisation scheme for airports: The first step is to define an airport categorisation scheme for the large heterogeneous mix of (European and generic) airports, enabling the definition of more homogeneous groups of (European and generic) airports. In this step advantage is taken from various categorisation schemes as defined in, for instance, [1], [4], [5] and [6].

- Criteria for selection of airports: The second step is to define criteria for the selection of (one or more) airports from each of the airport categories defined in the preceding step, in order to obtain a representative set of airports for consideration in CLAIRPORT's environmental-impact assessment. Criteria included: airports designated for regional and large-passenger aircraft, and continuity and consistency with the earlier Clean Sky TE project (2008-2016).

Based on this rationale, CLAIRPORT selected the European airports Amsterdam Airport Schiphol, Rome (Leonardo da Vinci –) Fiumicino Airport, Stockholm Arlanda Airport, Hamburg Airport and Toulouse Blagnac Airport, as well as the generic airport CAEPport.

2.2 Simulations and calculations

As mentioned above, the basic assessment principle of CLAIRPORT is to compare the environmental performance of two aircraft-traffic scenarios for a given combination of timeframe and airport. The methodology to quantify the environmental performance of such a scenario consists of two steps. Firstly, a realistic simulation of aircraft traffic is conducted, yielding for each flight a complete trajectory in the airport's local airspace respecting the real airport operational procedures and rules (e.g. aircraft movements are conflict free, in particular with respect to horizontal and vertical separation requirements). Secondly, the environmental contribution (in terms of noise, CO_2 and NO_X emissions) is calculated per flight, based on its trajectory. These environmental contributions per flight are then aggregated to obtain the total environmental impact results at airport level.

Consistent with the European Environmental Noise Directive 2002/49/EC and ICAO Doc 9889, CLAIRPORT assesses the following environmental-impact indicators:

- L_{den} and L_{night} contours for significant noise levels: Their surface area and the population exposed to these noise levels;
- Total amount of CO_2 and NO_X emitted below 3,000 ft.

2.2.1 Airport simulations

To simulate aircraft traffic at and around an airport, the fast-time airport (and airspace) simulation platform AirTOp is used. For each combination of timeframe and airport, AirTOp is fed with three classes of data:

- Airport layout (e.g. runways, taxiways, aprons, and stands), airspace layout (control zone and terminal manoeuvring area), and airport and airspace operations (e.g. runway and taxiway usage, departure separations, standard instrument departure routes, standard terminal arrival routes, vectoring and sequencing to obtain arrival separation, and radar and wake-vortex separation). To realistically account for the airport's operating procedures for different timescales, relevant developments in air traffic management are considered (for instance, developments emerging from SESAR and SESAR 2020).
- Aircraft performance characteristics to represent the aircraft's technical capabilities realistically (e.g. with respect to speed, climb/descend rates, and acceleration/deceleration).
- Flight schedules for cases with and without Clean Sky 2 concept aircraft.

AirTOp generates a realistic traffic output, which is input to aircraft noise and emissions models. Further, it provides airport capacity indicators such as runway throughput per rolling hour, to indicate whether Clean Sky 2 concept aircraft can be introduced and accommodated smoothly into daily airport operations.

2.2.2 Noise and emissions calculations

The airport-simulation output is a 4D trajectory for each flight in the flight schedule. Depending on the aircraft type associated with a trajectory, a specific aircraft noise and emissions model is used to calculate the noise, CO_2 and NO_X emissions generated by this flight: A trajectory flown by an LPA

reference-technology or concept aircraft is processed by the LPA's aircraft model Parametric Noise and Emission Model (PANEM); a trajectory flown by a REG reference-technology or concept aircraft is processed by the REG's aircraft model Regional Aircraft Simulation Model (RASM); and a trajectory not flown by an LPA or REG reference-technology or concept aircraft is processed by NLR's fully Doc29 compliant noise model Tuna and NLR's Boeing Fuel-Flow 2 method compliant LEAS-iT model.

The individual noise and emissions output are then aggregated to obtain the L_{den} and L_{night} contours (and their surface area) for significant noise levels as well as the total amount of CO_2 and NO_X emitted below 3,000 ft. Combining these L_{den} and L_{night} contours with population density data from Joint Research Centre (JRC), yields the population exposed to these noise levels.

2.3 Computation framework

Capitalising on the framework from the earlier Clean Sky TE project (2008-2016) for assessments at airport level, CLAIRPORT developed an efficient and effective computation framework to carry out the simulations and calculations for its environmental-impact assessment. This computation framework integrates all models and their databases, using state-of-the-art technologies.

The CLAIRPORT computation framework offers a flexible environment for integrating models and data. Performing calculations with a model is controlled by commands translated into hypertext transfer protocol (HTTP) requests, which contain all the relevant parameters and data necessary for the task. The application programming interface (API), which offers the Micro Services for performing the calculations, is the representational state transfer (REST) API. In order to perform a complete assessment, these requests are combined into workflows. The assessment data are stored in a database and can be accessed by users with the appropriate access permissions.

3. Airport-level assessment: Results

Applying the approach described in Section 2 (using flight schedules provided by Clean Sky 2 TE Leader DLR (German Aerospace Centre)), CLAIRPORT carried out its environmental-impact assessment. The assessment results indicate potential environmental benefits thanks to the integration of Clean Sky 2 technologies into concept fixed-wing aircraft.

For the year 2050, the reductions in surface area of L_{den} contours for relevant noise levels (60-65 dB(A)) are about 10-15% for the European airports. For the same noise levels (i.e. 60-65 dB(A) L_{den}) the noise results also highlight significant reductions of population exposed in the range of 10-25%. Further, in 2050, reductions of CO_2 emissions amount to about 8-13.5% for the European airports considered, while the associated NO_X reductions are roughly in the range 6.5-10.5%. Finally, there are no indications pointing to obstructions in the introduction and accommodation of Clean Sky 2 concept aircraft into daily airport operations.

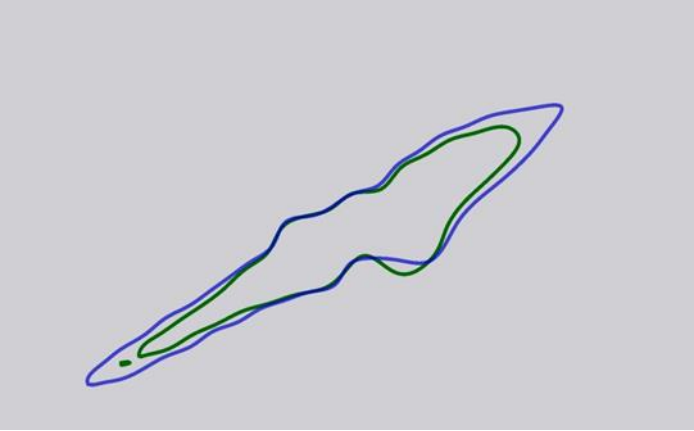

Figure 3 – CAEPport: 60 dB(A) L_{den} contour for year 2050 scenario without (blue) and with (green) Clean Sky 2 concept aircraft

4. Conclusion

The CLAIRPORT project successfully carried out its environmental-impact assessment at airport level of technologies developed in the Clean Sky 2 Programme for fixed-wing aircraft. Herewith, it contributed to the Clean Sky 2 First Global Assessment (cf. [2] and [3]).

This assessment clearly points to (significant) reductions in noise and emissions at and around the European airports considered, while its does not indicate any obstacle in the introduction and accommodation of Clean Sky 2 concept aircraft into daily airport operations. Furthermore, as only aircraft in seat classes 93-350 were equipped with Clean Sky 2 technologies, there is a clear potential for further reductions in noise and emissions at and around airports.

The CLAIRPORT project is succeeded by the project 'Clean Sky 2 Technologies for Greener Airports by 2050' (GREENPORT2050). The latter project will carry out the second airport-level assessment of Clean Sky 2 technologies for fixed-wing aircraft, while expanding CLAIRPORT's scope by e.g. enlarging the set of noise indicators, extending emissions impact to local air quality, expanding the assessment with third-party risk, and assessing Clean Sky 2 aircraft equipped with a more mature set of innovative technologies. GREENPORT2050's assessment results are expected mid-2023.

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Copyright Statement

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