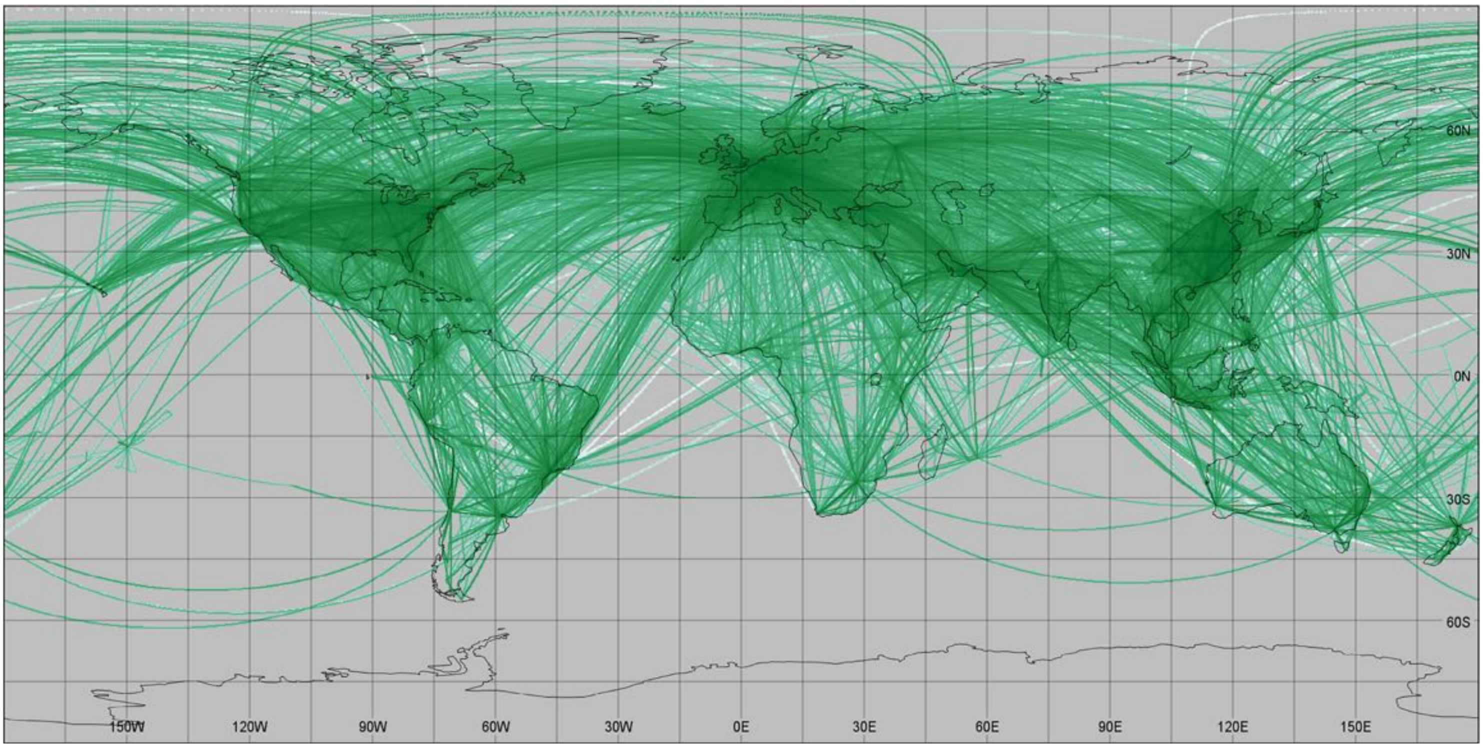
Technology Evaluator



FIRST GLOBAL ASSESSMENT 2020

Synopsis Report

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Foreword

ON THE ROAD TO A GREEN REVOLUTION IN AVIATION

Aviation's contribution to our economy is impressive – the sector supports almost 90 million jobs worldwide, with 13.5 million in Europe, and if aviation were a country in 2019, it would rank 17th in the world in terms of GDP, around the same size as the Netherlands. However, as we all know, the downside of flying is its impact on the environment.

Clean Sky 2 develops new and innovative technologies that support the transformation of aviation needed for a climate-neutral future. The work of Clean Sky 2 is evaluated through two different methods – one is at technology level, by evaluating the new technology in comparison with existing technology, using specific criteria such as fuel saving, weight saving, operational, maintenance or production improvements. The second method is at aircraft, airport and fleet level, through the Technology Evaluator. The role of the Technology Evaluator is to assess the environmental impact of these innovative technologies, when integrated into concept aircraft, and to determine the progress towards the programme's high level environmental objectives (for CO_2, NO_X, and noise).

This report presents the main findings of the first full Technology Evaluator Assessment of Clean Sky 2. This represents a major milestone in measuring the potential impact of the programme and verifying its value. It is the first of two assessments – the second and final one will be carried out in 2024. The full report can be found here.

While the Technology Evaluator Assessment did not take into account the impact of the Covid-19 pandemic, air travel is expected to recover within relatively short timeframes, so that by 2050 there will be only a modest impact on predicted air traffic volumes. In 2021, a new socio-economic impact study will include an analysis of the impact of the pandemic on the air transport system and on the current and future aeronautics research agenda.

This report highlights our main results, and the assessment methodology used. The environmental impact of Clean Sky's progress is evaluated on three levels: 'mission' or flight level, airport level, and fleet level. The assessment also takes our societal impact into account, explaining how Clean Sky 2's progress will impact jobs, connectivity and mobility. The interim results show very good progress towards the objectives set out in the regulation of the Clean Sky 2 programme, especially when taking into account that several technologies have yet to be integrated into the overall aircraft models.

It is important to highlight that the fleet level analysis outlines the extent of the challenge to reach the new goals of the European Green Deal – i.e. climate neutrality by 2050. It is clear that more needs to be done beyond Clean Sky 2, as part of the proposed Clean Aviation programme. If we want to achieve the zero-emission target by 2050, we will need game-changing aircraft to enter into commercial service *by 2035 at the latest.* Otherwise, the remaining time left would be too short to replace the then-flying less environmentally-friendly aircraft by 2050.

Time is of the essence – a rapid, radical, green revolution in aviation is needed. Clean Sky is proud to be a part of this journey and we look forward to what the future brings!

Axel Krein
Executive Director

Clean Sky 2 Joint Undertaking: Towards Climate-Neutral Aviation

WHAT IS THE FIRST GLOBAL ASSESSMENT?

The scope of this First Global Assessment 2020 synopsis report[1] is to provide an update on progress towards the high-level objectives of the Clean Sky 2 Joint Undertaking, a Public-Private-Partnership established by the European Commission in 2014[2].

WHAT ARE CLEAN SKY'S OBJECTIVES?

Clean Sky aims to develop ***cleaner air transport technologies for earliest possible deployment.*** That means integrating, demonstrating and validating technologies capable ***of reducing CO_2, 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, including those related to small aviation, the objective of Clean Sky 2 is also ***to develop a strong and globally competitive aeronautical industry and supply chain in Europe.***

WHAT IS THE TECHNOLOGY EVALUATOR?

The Technology Evaluator is a Transverse Activity, established by regulation for the entire duration of the Clean Sky 2 Joint Undertaking (i.e. until 31 December 2024) as an independent impact monitoring and assessment tool.

It is led by the German Aerospace Center (DLR) and has the following tasks (see boxes below).

Therefore, the First Global Assessment of the Clean Sky 2 programme covers two major aspects: the ***environmental impact assessment*** of the technologies developed under Clean Sky 2 research and the ***socio-economic impact assessment*** of the programme.

(i) monitoring and assessing the environmental and societal impact of the technological results arising from individual ITDs[3] and IADPs[4] across all Clean Sky activities, specifically quantifying the expected improvements on the overall noise, greenhouse gas and air pollutant emissions from the aviation sector in future scenarios in comparison to baseline scenarios;

(ii) providing feedback to ITDs and IADPs in order to enable the optimisation of their performance against their respective goals on objectives;

(iii) providing input, through the Executive Director, to the Governing Board on environmental and societal impacts across Clean Sky activities to enable the Governing Board to take all actions necessary to optimise benefits across all Clean Sky programmes, against the respective programmes' high-level goals and objectives;

(iv) providing regular information, through the members, the Executive Director and other bodies of the Joint Undertaking, on the impact of the technological results on the ITDs and IADPs.

1. The present document is a Synopsis of the full 1st Assessment Report also publicly available from www.cleansky.eu
2. Council Regulation (EU) No 558/2014 of 6 May 2014
3. ITD: Integrated Technology Demonstrator
4. IADP: Innovative Aircraft Demonstrator Platform

New Aircraft Concepts: Results at a Glance

In order to evaluate the environmental benefits of novel aeronautical technologies, several concept aircraft have been defined as well as their reference counterpart for comparison. These concept models are addressing the four major market segments: long range, short-medium range, regional and commuter/business jet.

The results at mission level underline the fact ***that substantial progress has already been achieved and that the programme is well on-track.*** Most of the concepts achieve their target or even exceed it.

MISSION LEVEL ASSESSMENT			
CONCEPT MODEL	$-CO_2$	$-NO_x$	NOISE
Long Range	-13%	-38%	< -20%
Short-Medium Range	-17% to -26%	-8% to -39%	-20% to -30%
Regional	-20% to -34%	-56% to -67%	-20% to -68%
Commuter and Business Jet	-21% to -31%	-27% to -28%	-20% to -50%
AIRPORT LEVEL ASSESSMENT			
	$-CO_2$	$-NO_x$	NOISE AREA
Airport Level	-8% to -13.5%	-6.5% to -10.5%	-10% to -15%
FLEET LEVEL ASSESSMENT			
	$-CO_2$	$-NO_x$	FLEET RENEWAL
Global Fleet Level	-14% to -15%	-29% to -31%	70% to 75%

The methodology as well as the detailed results at the three levels of assessment are described in the following sections of this document.

Methodology, Forecast & Scenarios

Although the high level objectives of Clean Sky 2 are set at aircraft level, this first assessment study covers three levels of environmental impact: mission level, airport level (including noise footprint) and fleet level, commonly named the Air Transport System.

To evaluate the global fleet assessment in 2050, predictions have been broken down into a forecast from 2010 until 2035 followed by two scenarios (high and low) up to 2050.

The DLR forecast until 2035 is more conservative than the commercial outlooks or global market forecasts but well-aligned with the ICAO CAEP/11 "most likely" forecast.

INNOVATION POTENTAL AT MISSION LEVEL

Clean Sky 2 Concept Aircraft are compared with 2014 Reference Aircraft on relevant missions regarding emissions and noise. The results are the basis to quantify the success level versus the Clean Sky 2 environmental goals.

REALISTIC IMPACT AT AIRPORT LEVEL

A typical day at a representative EU airport (fleet is from 2014 historical and 2035/2050 forecast data) is compared to a fleet with and without Clean Sky aircraft and analysed regarding emissions and noise.

AVIATION FOOTPRINT AT AIR TRANSPORT SYSTEM (ATS) LEVEL

A year with all global flights (fleet is from 2014 historical and 2035/2050 forecast data) is compared to a fleet with and without Clean Sky aircraft and analysed regarding emissions and noise.

The scenarios up to 2050 diverge according to their respective assumptions but they show that **air traffic in the year 2050 could reach volumes (in terms of revenue passenger kilometers) of 20 to 25 thousand billion,** an increase of 2-2.5 times the volumes of the year 2020.

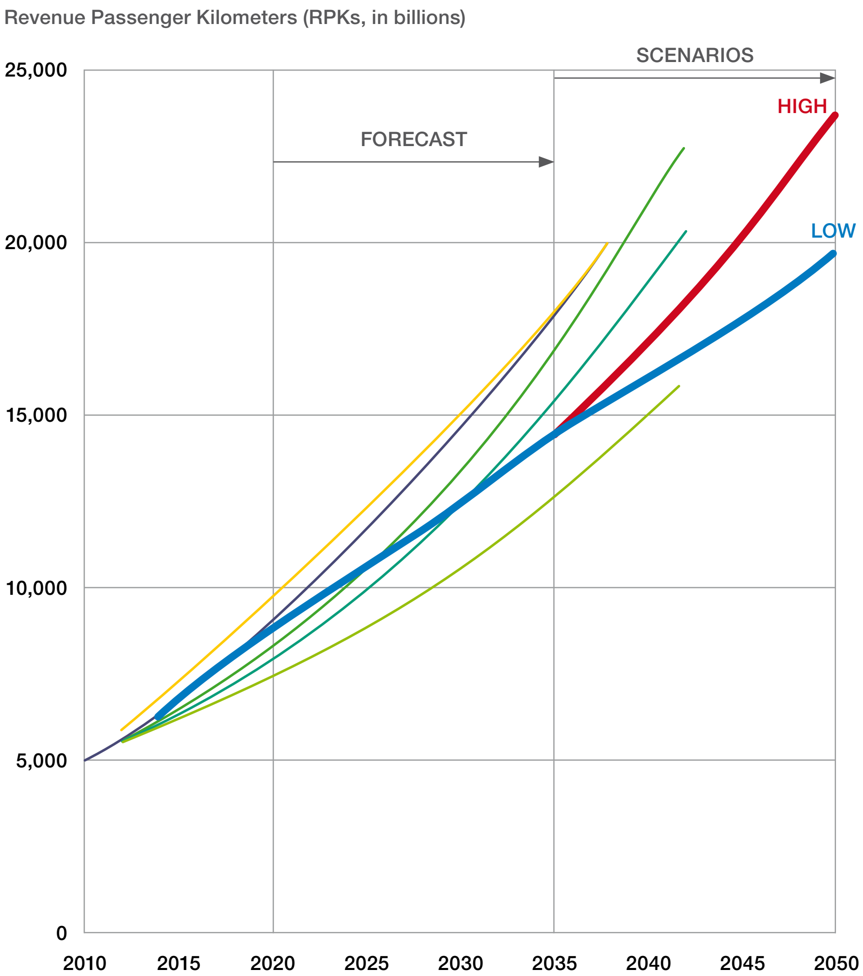
The study uses a DLR forecasting model based on various economic growth assumptions (GDP growth rate, world population and population growth rate, etc.), technology diffusion models and fleet replacement rates. It introduces an important novelty, as compared to other models dealing with air transport: **airport capacity constraints.**

Here, the model includes the mutual dependence between limited availability of additional airport infrastructure, air passenger demand growth and fleet mix evolution.

Comparisons are provided with the results of other models (such as ICAO-CAEP and Airbus/Boeing). To strengthen the credibility of this forecast, DLR has performed the same study without this assumption (i.e. an unconstrained forecast) for comparison.

This permitted the conclusions to be consolidated, demonstrating that ***a constrained forecast is likely to show an overall reduction of 30% in terms of flight volume.*** This is to be expected by 2050 versus an unconstrained forecast, with direct consequences for aircraft in service, hence on aircraft deliveries.

For the continuation of the programme, attention will be devoted to further testing the robustness of this model to extend it to new scenarios, in particular, since ***the impact of COVID-19 on aviation was not considered in this study.***



	2030	2040	2050
GDP growth rates (p.a. in % from 2014)	1.98	1.98	1.97
World population (in billions)	8.5	9.2	9.7
Population growth rates (p.a. in % from 2014)	1.05	0.93	0.86

AGR 2014 TO 2050

PASSENGER VOLUMES	FLIGHT VOLUMES
3.9% (High Scenario)	2.0% (High Scenario)
3.3% (Low Scenario)	1.7% (Low Scenario)

AIRPORT TRAFFIC CONGESTION

Congested airports are already a reality today. **An overall reduction of 30% in terms of flight volumes** can be expected if ***airport capacity constraints*** are taken into account in the forecast model. This is an important novelty of the DLR methodology compared to other models dealing with air transport today.

Environmental Impact

The assessment of the results in terms of environmental impact for each aircraft model is to be found in detail in the full report for the three levels of assessment respectively.

ASSESSMENT 1 AT MISSION LEVEL

The **mission level assessment** is based on detailed descriptions of each of the concepts and their technology insertions stemming from the work under the various ITD/IADP research streams. The technology selection and integration choice was performed as early as 2018 by each platform owner (for each vehicle model) before running the complete performance simulation. The definition of each aircraft concept was based on the available technologies that have sufficient levels of maturity in 2018 and the integration at overall aircraft level was performed accordingly, considering the mainly weight and volume impact of components and systems, efficiency and weight of the propulsion system and aerodynamic performance of the aircraft (at low speed and high speed). Each platform owner has used their respective in-house tools, which are proprietary performance simulation tools.

Synthesis results of mission level assessment for the Clean Sky 2 aircraft concepts, by aircraft category and seat class, all percentages related to best-in-class 2014 references

CATEGORY	SEATS	Concept Aircraft				Clean Sky 2 Environmental Goals			Clean Sky 2 1st Assessment Results			TRL Target** @ CS2 close
		Concept Vehicle	Range nm	Cruise speed	# PAX	ΔCO_2	ΔNO_x	Δ Noise	ΔCO_2	ΔNO_x	Δ Noise	
SAT-FRC-BJ	0-19	19 PAX Commuter	300	0.34 Ma	19	-20%	-20%	-20%	-21%	-27%	> -20%	4-5
		Low Sweep Business Jet	2900	0.78 Ma	12	> -30%	> -30%	> -30%	-31%	-28%	-50%	≥ 4
		Airbus Helicopters Compound (RACER)	<350	220 kTAS	12	-20%	-20%	-20%	+2 to +17%[8]	-24 to -36%	-16%	6
REGIONAL (EXTRA-SMALL)	20-100	Leonardo Helicopters Tiltrotor (NGCTR)	<1000	250 kTAS	24	-50%	-14%	-30%	-50 to -71%[9]	-12 to -50%	-86%	6
		Regional Multi Mission Turboprop 70 PAX – Transport Airline	1000	0.5 Ma	70	-20 to -30%	-20 to -30%	-20 to -30%	-20%	-59%	-20%	6
		Regional Multi Mission Turboprop 70 PAX – Transport Freighter	1000	0.5 Ma	n/a							
		Regional Multi Mission Turboprop 70 PAX – Search And Rescue (SAR)	400	0.5 Ma	15-25							
		Advanced Turboprop 90 PAX	1200	0.56 Ma at 20 kft	90	-19 to -25%	-19 to -25%	-20 to -30%	-34%	-67%	-68%	5
SMALL	101-210	Innovative Turboprop 130 PAX	1600	0.62 Ma at 30 kft	130	-35 to -40%	> -50%	-60 to -70%	-26%	-56%	-25%	4
		Advanced Short-Medium Range SMR+	2000	0.78 Ma	200	-20%	-20%	-20%	-17%	-39%	-20%	5
		Ultra-Advanced Short-Medium Range SMR++	2000	0.75 Ma	200	-30%	-30%	-30%	-26%	-8%[7]	<-30%	4
LARGE - MEDIUM	>300 / 211-300	Advanced Long Range LR+	6700	0.85 Ma	315	-20%	-20%	-20%	-13%[5]	-38%	<-20%	4
		Ultra-Advanced Long Range LR++	6700	0.85 Ma	315	-30%	-30%	-30%	-21%[6]	-45%[2]	n.a.	3

(*) All key enabling technologies at TRL 6 with a potential entry into service five years later.
(**) All key enabling technologies at major system level.
(5) LR+ CO_2 reduction (-13%) is made versus the A350-900 as reference aircraft, EIS 2015, a very highly optimized platform.
(6) LR++ engineering assumption of an additional -8% on CO_2 reduction and -7% on NO_x reduction versus LR+ concept.
(7) SMR++ (-8% NO_x) as CROR core engine model does not yet include low NO_x combustor technology, unlike SMR+ model (-39%).
(8) RACER results do not yet include ECO-Mode for single engine operation in cruise (an additional potential of -15%)
(9) NGCTR performance compared to AW139 helicopter
n.a. - not yet available
n/a - not applicable

Substantial progress has been achieved to date and the Clean Sky 2 programme can be considered well on-track. Most of the concepts achieve or even exceed their targets.

The regional aircraft are good examples of substantial improvements in terms of performance and promising solutions for better mobility (e.g. the Advanced Regional TurboProp (TP) 90 pax with -34% CO_2 and -67% NO_x reduction or the Innovative Regional TP 130 pax with -26% CO_2 and -56% NO_x).

For the mainliners (targeting an Entry-Into-Service date of 2030), the Short-Medium Range concept (SMR+) will achieve a significant improvement of -17% CO_2. The moderate improvement for the Long Range (LR+) concept (-13% CO_2) results from the comparison with the A350-900 as a reference, a very recent and already very highly optimised platform, while a substantial reduction in NO_x emissions has been obtained (-38%) thanks to the UltraFan® lean burn technology.

For the Ultra-Advanced concepts with EIS of 2035 and beyond, even more substantial gains can be expected, with -26% CO2 for the SMR++ concept (thanks to the Open Rotor architecture) and -26% CO_2 for the Innovative Regional TP 130 pax compared to a Regional Jet. The low NO_x reduction for the SMR++ (-8%) may be disregarded as it results from the core engine model of the Open Rotor not yet including low NO_x combustor technology (currently being updated). The LR++ (Ultra-Advanced LR concept) has not been modelled as a full aircraft concept but rather an engineering approach has been taken with an additional -7% to -8% improvement versus the LR+ concept has been assumed (-21% CO_2 reduction and -45% NO_x). This concept will be fully developed for the 2nd assessment.

Commuter and business jet concepts are achieving and exceeding their targets as well, whereas the results reported so far for rotorcraft are highly dependent on the choice of the reference vehicle as no commercially available helicopter can compete with these new hybrid concepts in terms of performance.

Still, this is a snapshot of the results at programme mid-term. ***More progress and further performance improvements can be expected over the second part of the programme through further maturation of the technologies and updates of the models as well as inclusion of additional technologies not yet considered today.***

The mission level performance results are the basis for the subsequent airport and fleet level calculations.

ASSESSMENT 2 AT AIRPORT LEVEL

The **airport level assessment** also shows substantial improvements thanks to the progress made in noise reduction technologies.

Noise impacts were estimated by comparing the noise performance of future airport traffic scenarios with and without Clean Sky 2 technologies in the year 2050 for a set of representative airports (Amsterdam Schiphol, Rome Fiumicino, Stockholm Arlanda, Hamburg, and Toulouse Blagnac). The reductions for 2050 in surface area of Lden contours for relevant noise levels (60-65 dB(A)) are about 10-15% and point **out** ***significant reductions of 10-25% in population exposed and population highly annoyed.***

In 2050, ***reductions of CO_2 emissions will amount to about 8-13.5% for the European airports considered, while the associated NO_x reductions are in the range of 6.5-10.5%.***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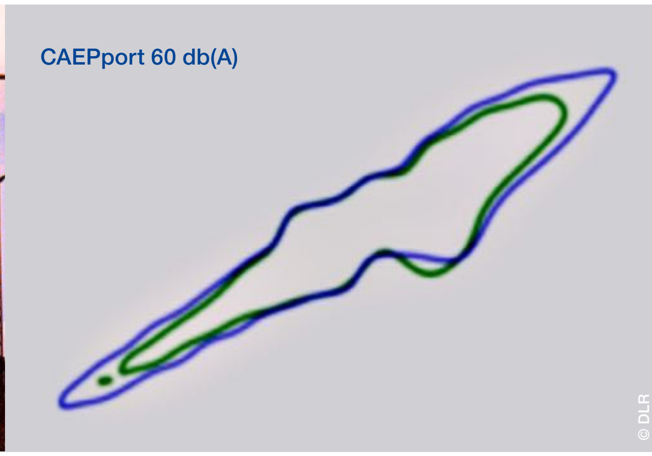

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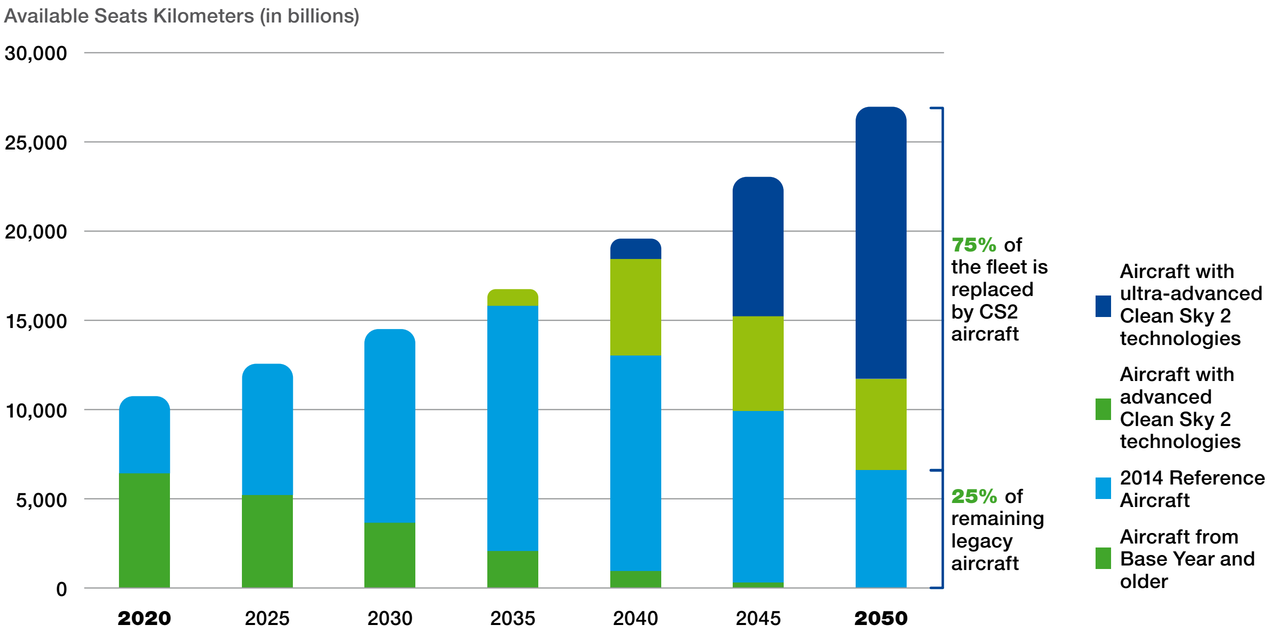
ASSESSMENT 3 AT FLEET LEVEL

At **fleet level** (Air Traffic System), according to the present forecast (high scenario), approximately ***75% of global available seat kilometres (ASK) will be operated with aircraft expected to carry Clean Sky 2 technologies in 2050,*** while 25% of global ASKs will still be operated by aircraft with 2014 reference technologies, not yet retired.

By applying the performance improvements obtained for each concept aircraft, and by completing the fleet with virtual aircraft based on appropriate technology diffusion models to neighbouring seat classes, ***an overall reduction of CO_2 and NO_x emissions of about 15% and 31% per seat kilometre can be expected for the year 2050 high fleet scenario as compared to a 2050 global traffic scenario*** incorporating only 2014 reference technology.

For the 2050 low scenario, these values are slightly lower (about 14% CO_2 and 29% NO_x) as the share of Clean Sky technology aircraft in terms of ASK is slightly smaller – about 70% compared to the high scenario of 75%.

Clean Sky 2 fleet replacement scenario by 2050



As a comparison, if all new concepts would achieve 20 to 30% performance improvement, and if 100% of the fleet could be replaced within the next 30 years, a maximum of 20 to 30% reduction in CO_2, NO_x and noise emissions could be expected.

Unfortunately, considering the long development times of a new aircraft as a commercial product (between 5 to 10 years), their extremely long service life (on average 25 years for mainliners, 29 years for turboprops), and the inertia in production rate increase (despite some substantial ramp-up in recent years), the fleet replacement process is slow. ***It is therefore crucial to target the earliest entry into service date for the next generation of aircraft.***

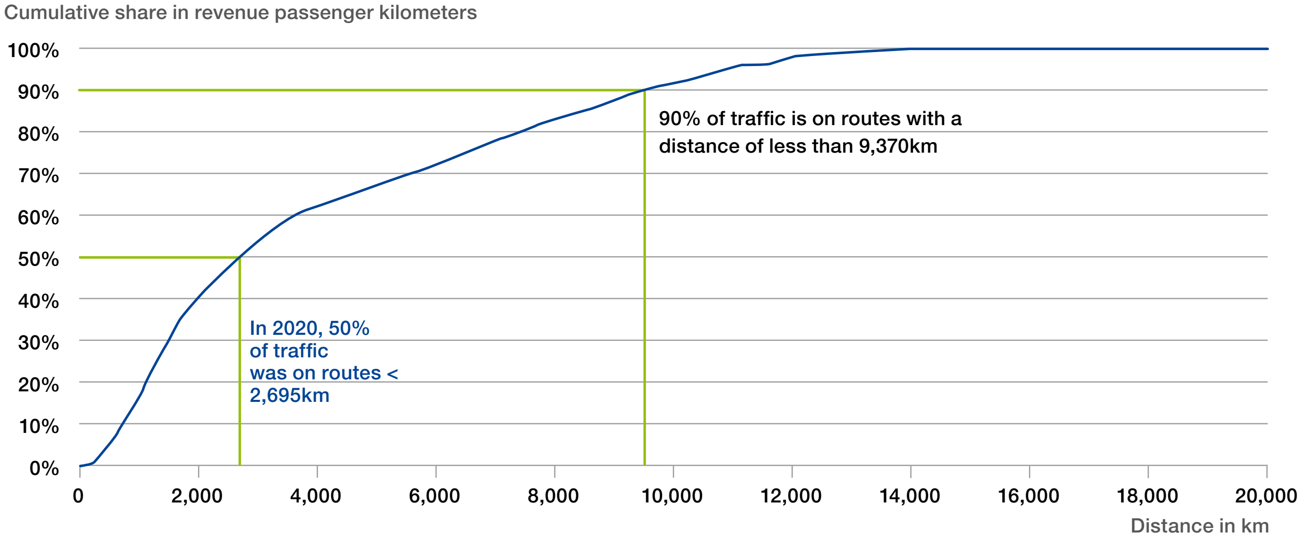
Historically, the time between two aircraft generations has been typically 15 to 20 years. This also underlines ***the urgent need to accelerate the technology maturation process by promoting and supporting research investments, in order to "skip a generation".*** To this end, not only advanced technologies but possibly also ultra-advanced technologies should be integrated simultaneously onto the next aircraft generation by 2030, if not, by 2035 at the latest.

As regards fleet evolution, the model predicts ***a major shift towards larger aircraft (>300 seats) mainly to be used to fly short range (<4000km)*** for the mainliner seat class.

Today, 50% of traffic is on routes that are shorter than 2700 km. However, most of the aircraft travelling these routes are capable of flying much longer distances.

It is expected that the discrepancy between the design range and operational use will considerably increase in importance in the future.

Cumulative Distribution of RPKs over Distance (relative)



Regarding the share of CO_2 generated by the traffic in 2050, ***90% of the flights will be on routes less than 3 000 kilometres (regardless of aircraft size) and will account for almost 60% of total aviation CO_2 emissions,*** a 10% increase compared to 2020. This increase occurs despite the assumption that 75% of the fleet will have been replaced by new Clean Sky 2 concept aircraft with a -20 to -30% CO_2 reduction improvement in performance.

By 2050, the percentage global share of emissions released by aircraft on long-range flights of over 10 000 km will decrease to 6%. This will be a 3% decrease compared to 2020, and will be attributed to improvements in performance thanks to the long-range Clean Sky 2 concepts, and either a slight increase or no change in the number of flights on these routes.

AIR TRAFFIC CARBON EMISSIONS IN 2050

In 2050, more than 55% of CO_2 emissions will come from medium and large aircraft ***on short-medium haul flights*** *(<4000km).* ***These two aircraft categories will account for about 55% of flights, compared to 15% in 2020.***

		Flight Distance (km)													
Aircraft Class	Seats	0-1000	1000-2000	2000-3000	3000-4000	4000-5000	5000-6000	6000-7000	7000-8000	8000-9000	9000-10000	>10000	CO_2	Flights	Passenger-km
Commuter	0-19												0.04%	1.5%	0.01%
Extra-Small	20-100												1.1%	9.6%	0.8%
Small	101-210												11.7%	33.7%	12.3%
Medium	211-300												26.8%	28.1%	22.0%
Large	>300												60.3%	27.2%	64.8%
CO_2		19%	26%	14%	8%	4%	5%	5%	4%	4%	4%	6%	Share of total in 2050		
Flights		54%	28%	8%	3%	1%	1%	1%	1%	1%	1%	1%			
Passenger-km		15%	25%	14%	9%	5%	5%	6%	5%	5%	5%	8%			

Share of total CO_2 emisions: 0% | 0%-0.1% | 0.1%-2% | 2%-5% | 5%-10% | 10%-15%

The share of CO_2 emissions from short- and medium-range aircraft (flights with 101-210 seats and flights with 211-300 seats, respectively) will be reduced to less than 40% versus more than 60% in 2020. This 20% decrease in CO_2 emissions will be caused by a reduction of over 10% in the number of flights in that same category, which is almost entirely transposed to the large aircraft category – now accounting for more than 25% of flights versus 5% in 2020. As the long-range flights over 10 000 km will remain practically unchanged, it is clearly visible that this increase will predominantly affect short-haul traffic flying distances of less than 3 000 km or up to 4 000 km for the largest aircraft.

The share of CO_2 emissions caused by regional (fewer than 100 seats) and commuter (<19 PAX) flights has decreased from 5% to only about 1%, as these aircraft are projected to serve only 10% of the flights in 2050 versus 25% of today's flights.

A VERITABLE "SKY-BUS"

Like the famous London double-deckers, high passenger capacity will be key to responding to air traffic demand in the future, especially on short-haul routes (<4,000km). As a result of airport capacity constraints, a veritable "aerial autobus" of large capacity will be required to move passengers from city to city mostly on intra-continental flights.

The 2050 data therefore strengthens the conclusion that the ***main focus on decarbonising aviation should be on short-range aircraft flying distances of less than 4 000 km, however with much larger passenger capacity, well over 300, even over 400 passengers in the cabin.*** This type of aircraft does not exist today.

In order to satisfy the mobility demand and operational missions in 2050, one recommendation is ***to introduce such an additional aircraft concept,*** often called a "people mover" in the aeronautical community.

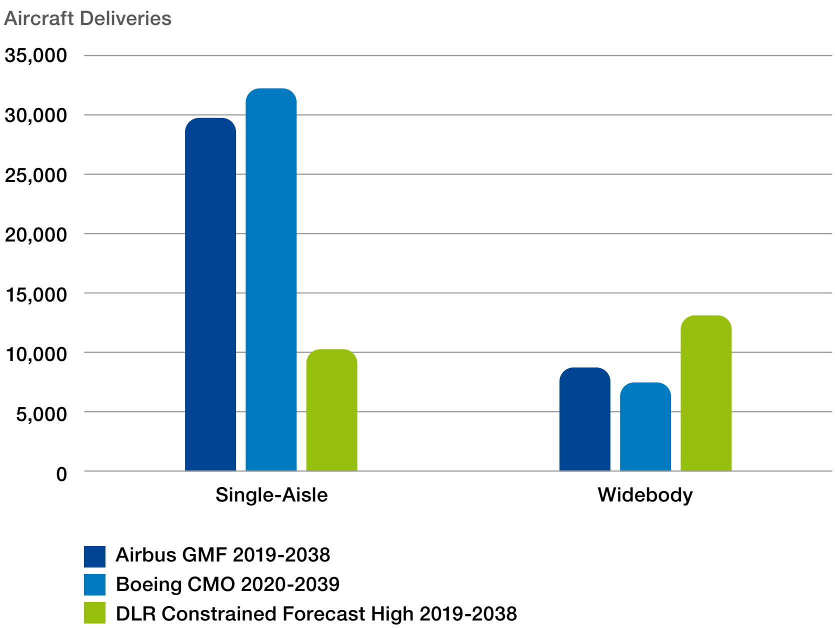
Modelling a relevant aircraft concept which would satisfy this fleet prediction will therefore be a major focus of the second assessment. The implications of this result as regards the environmental impact of Clean Sky 2 and the implications for policy/regulatory interventions will also be further explored.

In terms of impact on aircraft deliveries, and in order to compare with existing forecasts (e.g. the Airbus Global Market Forecast 2019-2038 or the Boeing Commercial Market Outlook 2020-2039) the DLR data has been extracted for the year 2038 for the constrained high scenario.

The present study foresees only about 10,000 new deliveries in the single-aisle market instead of 30,000 as predicted by the industry forecasts. This will be to the benefit of the medium and large seat classes which will increase respectively by 30 and 50%. The expected deliveries in widebody aircraft in general (twin-aisle) is exceeding 13,000 units compared to about 8,000 as seen by industry.

By 2038, about 1,500 aircraft would need to be delivered for the SAT market and about 3,500 for the regional market to satisfy demand.

Estimated aircraft deliveries by 2038



AIRCRAFT DELIVERIES WILL DROP

As a result of reduced flight volumes (-30%) entailed by the increasing congestion at airports, aircraft deliveries will drop accordingly. The present study foresees only about 10,000 new deliveries in the small seat class (101-210 seats) instead of 30,000 (as predicted by industry) to the benefit of the medium and large seat classes which will increase respectively by 30 and 50%.

Societal Impact

The **societal impact** of the Clean Sky 2 programme covers mobility and connectivity benefits, macro-economic impact at aviation level (GDP growth, Gross Value Added (GVA), job creation) as well as competitiveness and impact on society.

Regarding **mobility and connectivity,** the introduction of SAT commuter aircraft (800km range, 300km/h cruise speed), shows that the ***percentage of a population accessible within 4 hours*** (one of the ACARE goals for door-to-door mobility) ***can be substantially increased up to ~30%,*** up to ~37% if cruise speed is increased to 400km/h.

Both fast rotorcraft concepts, as well as the multi-mission 70 pax regional turboprop, provide substantial improvements for valuable missions such as Search and Rescue (SAR), fast medical evacuation or Emergency Medical Services (EMS), but also simply for passenger transport thanks to their increased flight speed and reduced connecting time. The results of several mission simulations such as Airport Hub-Feeder (AHF) or Commercial Intercity Passenger Transportation (CIT) support this conclusion by substantial flight time reductions of between 25% and 43%.

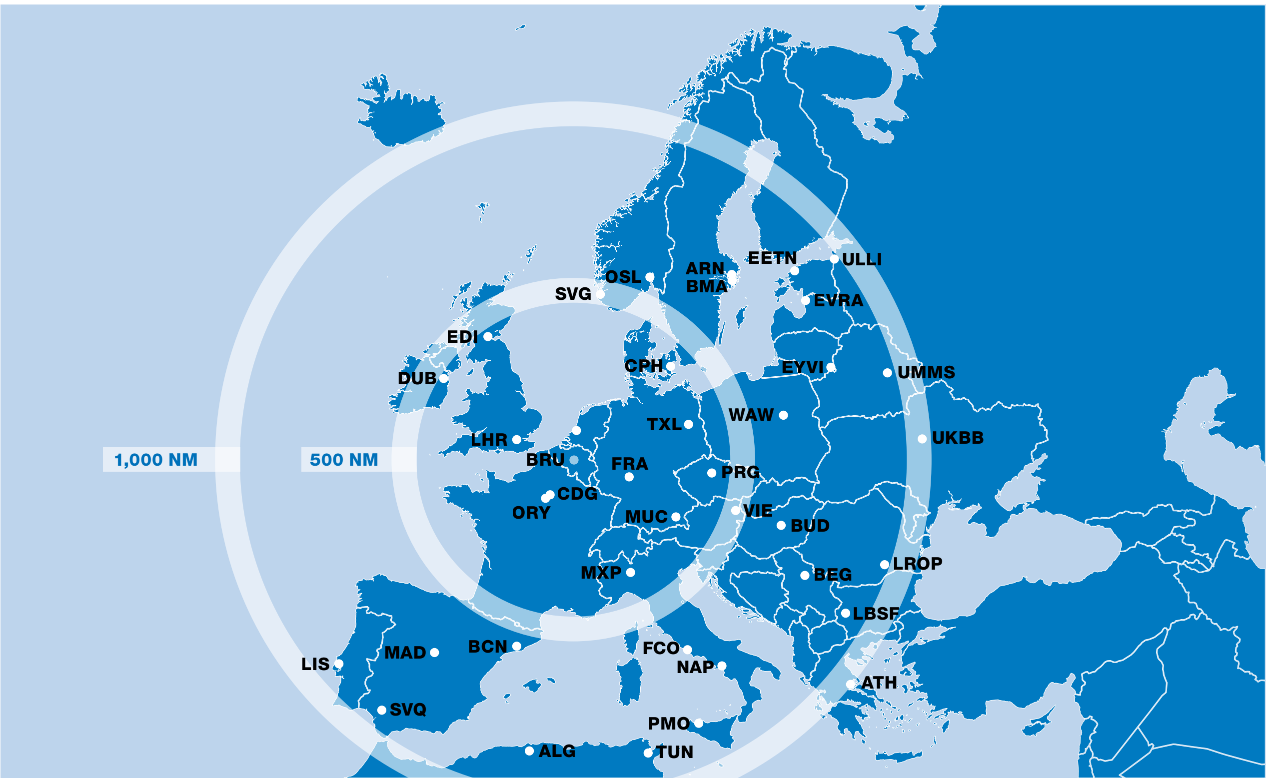
In the EU-28 at **macro-economic** level, aviation is responsible for an above-average share of total GVA and total employment compared to the rest of the world.

The projection indicates strong positive growth in aviation-related employment in Europe and in the world as well as a significant increase in gross value added created by aviation.

Based on the movements forecast and an economic input-output model using data from the World Input-Output Database[10], the economic effects of civil aviation, which are supported by Clean Sky 2, have been estimated in terms of GVA and employment growth. Although a significant driver is the strong air traffic growth in emerging economies such as China, India, and Indonesia, **the EU28 (and the US) will see both their employment and GVA from aviation roughly double by 2050 versus 2014, maintaining a significant share of the world's global aviation-related employment and GVA.**

CONNECTIVITY

Most of Europe can be covered with flights below 1000 nautical miles, (approximately 1800 km) out of Brussels Airport.



10. Cf. http://www.wiod.org/home

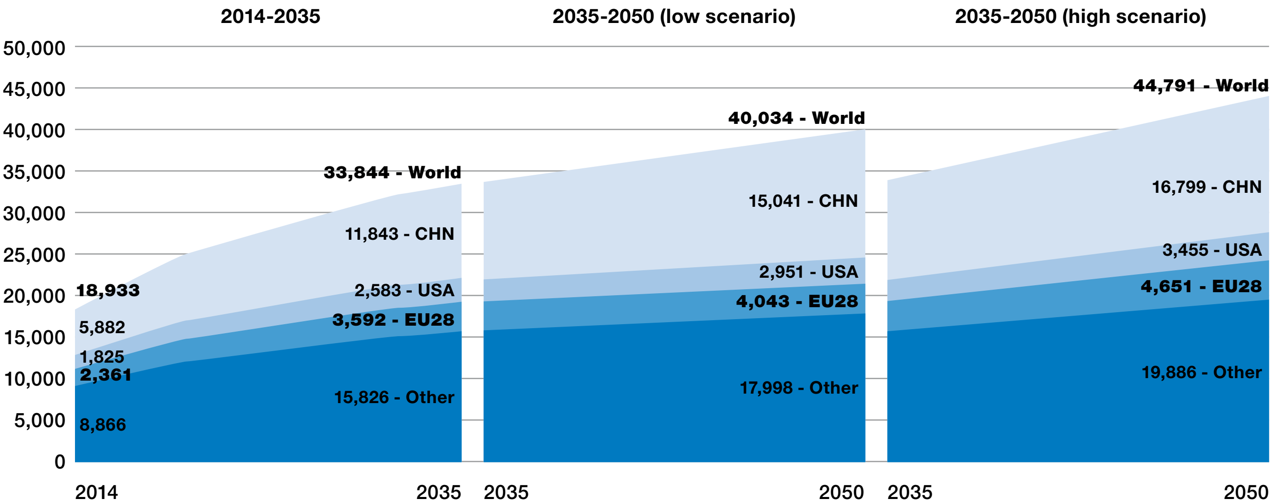
Regarding **competitiveness and societal impact,** as a result of this first assessment, all stakeholders acknowledge that Clean Sky 2 contributes positively to the improvement of the technical know-how, competitiveness and job creation in the EU industry. The structure of Clean Sky 2 enables all actors in the aviation community to collaborate and share ideas easily. Researchers can learn what the industry's needs are, and SMEs can gain access to industry leaders and their facilities. In turn, industry benefits from the innovative potential of SMEs and the deep specialised knowledge of the research centres and academia.

Clean Sky has successfully established a robust innovation network and quality supply chain in the aviation sector, motivated to drive cleaner, greener aviation forward.

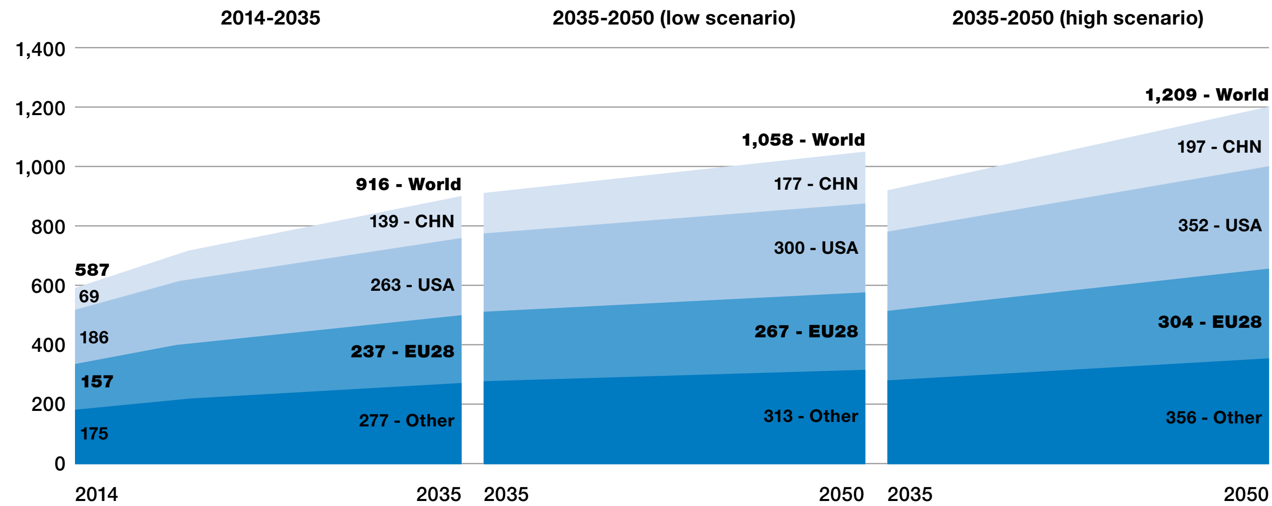
By the end of 2020, four Calls for Core Partners and eleven Calls for Proposals were launched and evaluated. Through these call mechanisms, the €4 bn budget / €1.8 bn funding Public-Private Partnership programme attracted an unprecedented number of participants. More than 940 entities are currently involved in more than 550 project grants with a broad geographical spread. Many newcomers from other sectors (e.g. automotive) joined the programme, providing key innovation impetus. Statistics show high SME participation with many SMEs being first-time EU programme participants as well. **More than 5 000 engineers and scientists around Europe are working on Clean Sky 2 projects.**

As already briefly mentioned, **the impact of COVID-19 has not been accounted for in the present study.** The work was finalised during the first outbreak of the pandemic in Europe. Nevertheless, some reflections addressing the potential impacts in the short-, medium- and long-term on demand, movements and network, as well as on the global fleet are proposed in the full report.

Employment created by aviation between 2014 and 2050 (in thousand jobs)



Gross value added (GVA) by aviation between 2014 and 2050 (in Bn€)



Outlook Towards Final Assessment

Let us close with an outlook towards the second (and final) assessment of 2024. Work has already started with a new iteration of technology mapping to include additional technology bricks into the existing concept models and update them.

New or updated reference vehicles will be defined to improve performance comparison.

New aircraft concepts as well as new engines will be proposed to further reduce the environmental impact by better addressing the needs of the fleet in 2050.

The socio-economic impact study will be updated to address not only direct, indirect and induced effects but also catalytic effects. The impact of COVID-19 may play a major role here. The study will be extended to address in further depth the impact on European competitiveness and the "additionality" of Clean Sky 2 as a Public-Private Partnership in the aeronautical landscape.

Funded by the EU's Horizon 2020 programme, Clean Sky contributes to strengthening European aero-industry collaboration, global leadership and competitiveness by delivering innovative solutions for the aviation sector.

Clean Sky's long-term vision is to enable the EU aviation sector to reach complete climate neutrality by 2050. Achieving such an ambitious goal requires sector-wide cooperation, and Clean Sky engages and supports SMEs, universities, research centres and the aviation industry to continue to deliver ground-breaking results.

TECHNOLOGY EVALUATOR

The role of the Technology Evaluator is to assess the environmental impact of the innovative technologies under development in Clean Sky when integrated into concept aircraft and rotorcraft. It determines the extent of Clean Sky's contribution to the environmental objectives of CO_2, NO_x, and noise.

3 LEVELS OF ASSESSMENT

LEVEL 1 AT MISSION LEVEL

LEVEL 2 AT AIRPORT LEVEL

LEVEL 3 AT FLEET LEVEL

CLEAN SKY 2 OBJECTIVES 2014-2024*

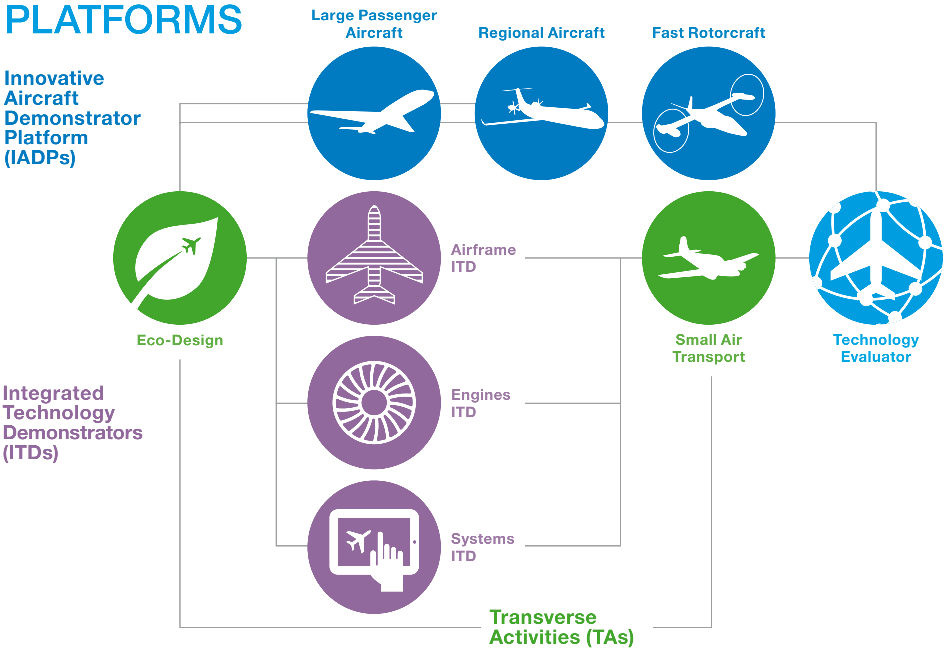
$-CO_2$: -20% TO -30%

$-NO_x$: -20% TO -30%

Noise: -20% TO -30%

* Refers to the impact at mission level of technology developed in Clean Sky 2 compared to state-of-the-art aircraft from 2014

CLEAN SKY 2 PLATFORMS



FIRST GLOBAL ASSESSMENT RESULTS – 2020

MISSION LEVEL ASSESSMENT			
CONCEPT MODEL	$-CO_2$	$-NO_x$	NOISE
Long Range	-13%	-38%	< -20%
Short-Medium Range	-17% to -26%	-8% to -39%	-20% to -30%
Regional	-20% to -34%	-56% to -67%	-20% to -68%
Commuter and Business Jet	-21% to -31%	-27% to -28%	-20% to -50%
AIRPORT LEVEL ASSESSMENT			
	$-CO_2$	$-NO_x$	NOISE AREA
Airport Level	-8% to -13.5%	-6.5% to -10.5%	-10% to -15%
FLEET LEVEL ASSESSMENT			
	$-CO_2$	$-NO_x$	FLEET RENEWAL
Global Fleet Level	-14% to -15%	-29% to -31%	70% to 75%**

** Percentage of aircraft replaced by Clean Sky 2 technology aircraft concepts by 2050

Find out more at **www.cleansky.eu**

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Clean Sky 2 JOINT UNDERTAKING