International Civil Aviation Organization

CAEP/13 Complementary Supersonic Study:

ESTIMATING NOISE AND EMISSIONS OF SUPERSONIC AVIATION OUT TO 2050

ABOUT THE CAEP

The **Committee on Aviation Environmental Protection (CAEP)** is a technical committee of the ICAO Council established in 1983. CAEP assists the Council in formulating new policies and adopting new Standards and Recommended Practices (SARPs) related to aircraft noise and emissions, and more generally to aviation environmental impact.

CAEP undertakes specific studies, as requested by the Council. Its scope of activities encompasses noise, local air quality (LAQ), and a basket of measures to reduce international aviation CO2 emissions, including aircraft technology, operational improvements, sustainable aviation fuels, and market-based measures (CORSIA).

CAEP informs the Council's and Assembly's decision-making with the ICAO Global Environmental Trends, which assess the present and future impact of aircraft noise and aircraft engine emissions. The Global Environmental Trends is crucial to ICAO's work, as it provides a robust, single reference for sound discussion and decision-making.

The Council reviews and adopts CAEP recommendations, including amendments to the SARPs, and in turn reports to the ICAO Assembly, where the main policies on environmental protection are ultimately defined.

NOTES

This study was produced by the **CAEP - Modelling and Database Group (MDG)** during the CAEP/13 cycle, following approval by the 2025 CAEP Steering Group meeting, which took place from 1 to 5 December 2025.

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ESTIMATING NOISE AND EMISSIONS OF SUPERSONIC AVIATION OUT TO 2050

CAEP/13 Complementary Supersonic Study

- DECEMBER 2025 –

ABSTRACT

Between 2019 and 2025 the ICAO Committee on Aviation Environmental Protection (CAEP) performed two consecutive studies aiming to estimate the potential share of supersonic aircraft in aviation's total noise and emissions in the future. This report presents the results of the second study performed during the CAEP/13 cycle, named 'Complementary Supersonic Study (CSS)'. The study provides an outlook of supersonic aircraft demand, noise and emissions to 2050 for multiple scenarios, including scenarios with low-boom designs and unrestricted overland supersonic flights. It finds that, while future demand for supersonic travel is still uncertain, supersonic aircraft have the potential to consume a significant part of the reductions in fuel burn and landing and take-off noise that may be achieved in the subsonic fleet.

ACRONYMS

AAT	Aircraft Assignment Tool
BJ	Business Jet
CAEP	Committee on Aviation Environmental Protection
CO_2	Carbon dioxide
CSS	(CAEP) Complementary Supersonic Study
dB	decibel
DLR	Deutsche Zentrum für Luft- und Raumfahrt
DNL	Day-Night average sound Level
EASA	European Union Aviation Safety Agency
EC	European Commission
EPNdB	Effective Perceived Noise decibel
EUROCONTROL	Pan-European, civil-military organisation dedicated to supporting European aviation
ICAO	International Civil Aviation Organization
IE	(CAEP) Independent Experts
IEIR	(CAEP) Independent Experts Integrated Review
LTO	Landing and Take-Off
MIT	Massachusetts Institute of Technology
MTOW	Maximum Take-Off Weight
NOx	Nitrogen oxides
OL	Overland
PAX	Passenger
SEL	Sound Exposure Level
SST	Supersonic Transport

1. INTRODUCTION

Industry is working to revive supersonic transport (SST) both for the airliner and business jet markets [1]. While new SST aircraft are expected to have a better environmental performance than their predecessors like the Concorde or the Tupolev Tu-144, the size of the fleet and number of flight operations could be larger. In particular, if overland supersonic flights are made possible by low-boom designs the number of city pairs with a supersonic connection may become significantly greater than in the Concorde era.

As ICAO's environmental trends presently do not take into account supersonic aviation, the ICAO Committee on Aviation Environmental Protection (CAEP) decided to perform two consecutive studies aiming to estimate the potential share of supersonic aircraft in global aviation's noise and emissions in the future. The first study, named 'Exploratory Study for Supersonic Aircraft', focused on oversea supersonic operations by year 2038, and its outcome was reported to the CAEP/12 meeting [9].

This report presents the results of the second study performed during the CAEP/13 cycle, named 'Complementary Supersonic Study (CSS)', which provides an outlook to 2050 and includes scenarios with low-boom designs and unrestricted overland supersonic flights. The report is structured as follows:

- Section 2 presents the supersonic concept aircraft considered in the CSS with their high-level characteristics, as well as the assumed demand for those (see also Appendix A).
- Section 3 presents the assumptions for the subsonic fleet demand.
- Section 4 and Appendix B present the 11 scenarios used in the CSS.
- Section 5 and Appendix C contain the results of the CSS noise assessment.
- Section 6 and Appendix D contain the results of the CSS fuel burn and emissions assessment.
- Section 7 summarises the main findings of the study.
- Section 8 provides a list of references.

2. SST AIRCRAFT AND DEMAND

This section presents the supersonic concept aircraft of the CSS and their respective demand in terms of fleet, routes and operations under various scenarios.

2.1 SST aircraft

For the purpose of this study, the supersonic market is split in two sub-markets: the business jets and the airliners. A single concept aircraft is used to fulfil the demand in each sub-market. However, the landing and take-off noise, fuel efficiency and engine emissions characteristics of each SST aircraft are expressed as a range of three values (low, mid, high), with "low" representing the aircraft with lowest noise levels, fuel burn or emissions. The characteristics of the SST aircraft used in the study are summarised in Table 1

The noise levels reflect the assumption that SST aircraft will meet the Annex 16 Volume I Chapter 14 noise limits for subsonic aircraft [14], with some additional built-in margin. The average fuel efficiency and NOx emission values reflect the range of data collected from manufacturers and various research projects [2][3], noting that the uncertainty on emission characteristics of supersonic engines is still high. These average values take into account the mix of subsonic and supersonic flight phases.

In absence of identified data sources for low-boom aircraft, their main characteristics are assumed to be identical to those of the conventional-boom aircraft. Low-boom aircraft are assumed to generate sufficiently low en route noise levels, including at supersonic speed, thereby enabling operations at supersonic speed overland [13].

Table 1.A Performance characteristics of the CSS supersonic aircraft

Market	Max Take-Off Weight	Number of Seats	Number of Engines	Max Mach Number	Max range at max speed
Business jet	60 t	n/a	2	1.4	4,000 nm
Airliner	150 t	65	4	1.7	4,250 nm

Table 2.B Environmental characteristics of the CSS supersonic aircraft

Market	Cumulative noise margin to Chapter 14 (EPNdB) (low / mid / high)	Average fuel burn (kg) per flown km (low / mid / high)	Average NOx emissions (g) per kg fuel burn (low / mid / high)
Business jet	-6 / -4 / -2 EPNdB	3.0 / 3.5 / 4.0 kg/km	9.0 / 11.0 / 13.0 g/kg
Airliner	-6 / -4 / -2 EPNdB	7.5 / 9.0 / 10.5 kg/km	11.0 / 13.0 / 15.0 g/kg

2.2 SST demand

Demand data from various SST studies was compiled which can be found in Appendix A. Some of these studies provide data for various scenarios, while others only include one scenario. Only three studies with demand data for low-boom (overland) supersonic airliner operations were identified, one of which only for year 2035. No study was found with demand data for low-boom supersonic business jet aircraft.

The demand data from the study by EUROCONTROL, EASA and DLR [10] is the one used for the CSS, as it covers the broadest range of aircraft categories, including low-boom airliner demand, and covers the range of demand volume across all studies identified in Appendix A. SST airliner market penetration in this study is consistent with that in the MIT study [8]: in the EUROCONTROL-EASA-DLR study, SST airliner demand including overland supersonic operations in 2050 represents 0.2% / 1.2% / 2.9% of total passenger demand expressed in seat-kilometres for the low / mid / high scenarios respectively (see Appendix B), against 0.8% / 1.5% / 3.0% in the MIT study.

SST airliner demand is derived by identifying viable routes with EUROCONTROL’s *himach* model [16], i.e. airport pairs where SST aircraft can offer flight time reductions above a minimum threshold, estimating the total subsonic premium (business and first class) seats on those routes and assuming which share of those seats would be replaced with supersonic seats. The number of aircraft in service is derived from the total annual flight-hours divided by an assumed average SST airliner aircraft utilisation (block-hours per aircraft per year).

SST business jet demand is derived from an estimated number of SST aircraft in service combined with an average aircraft utilisation (number of flights per year). The SST business jet route network is a subset of the most frequently flown subsonic business jet routes.

Since no study was identified with demand data for low-boom supersonic business jets, the CSS assumes that one such aircraft 1) enters into service approximately ten years after the conventional-boom business jet (e.g., towards 2040) and 2) is produced at the same rate (same number of annual deliveries) and has the same utilisation until 2050, similarly to how 2050 operations were derived for conventional-boom business jets. The low-boom business jet is assumed to use the same route network as the conventional-boom business jet, which mostly consists of overland routes. With such assumptions, SST business jet operations represent 1.2% / 2.6% / 4.5% of subsonic business jet ones in the 2050 low / mid / high overland scenario respectively.

For each sub-market, demand is estimated for three scenarios (low, mid, high) without and with overland supersonic operations. The resulting SST airliner and business jet demand data is summarised in Table 3.

Table 3. CSS supersonic aircraft demand

Year	**Demand Scenario**	**SST Business Jet**			**SST Airliner**		
		# of aircraft	**# of routes 1-way**[1]	**Annual operations**	**# of aircraft**	**# of routes 1-way**	**Annual operations**
2038	Low	200	3,955	20,000	28	80	21,300
	Mid	350	5,617	47,250	268	472	189,800
	High	500	6,730	85,000	742	844	523,750
2050	Low	440	3,955	44,000	64	156	48,150
	Low w/ Overland	680	3,955	68,000	133	448	130,250
	Mid	770	5,617	103,950	468	674	337,300
	Mid w/ Overland	1,190	5,617	160,650	1,037	2,154	989,900
	High	1,100	6,730	187,000	1,303	1,160	934,450
	High w/ Overland	1,700	6,730	289,000	2,912	3,680	2,767,350

3. SUBSONIC FLEET DEMAND

For subsonic demand, the CSS uses the operations by aircraft type and airport pair from the EUROCONTROL-EC-EASA Aircraft Assignment Tool (AAT) for the CAEP/12 COVID-adjusted low, central and high demand forecasts, i.e. the same operations as used in the CAEP/12 environmental trends [4]. This ensures the consistency between the supersonic demand and subsonic demand in the CSS, as the supersonic demand presented in previous section was derived from the same CAEP/12 COVID-adjusted subsonic demand forecast.

The CSS assumes that demand displacement occurs in the passenger market segment but not in the business jet one, i.e.: supersonic airliners cause some reduction in subsonic passenger operations on the routes where they operate, but supersonic business jets do not cause a reduction in subsonic business jet operations. The AAT operations for the subsonic passenger market segment were adjusted accordingly (reduced) to account for the displacement in this market.

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[1] '1-way' means that routes from airports A to B and B to A count as two distinct routes.

Under the central scenario, the 2050 subsonic business jet and passenger in-service fleets consist of around 35,000 and 70,000 aircraft respectively.

Table 4 shows the subsonic operations for all three markets in the subsonic forecast (passenger, business jets and cargo) in 2038 and 2050 before demand displacement in the passenger market. Under the central scenario, the 2050 subsonic business jet and passenger in-service fleets consist of around 35,000 and 70,000 aircraft respectively.

Table 4. CSS subsonic demand (without displacement)

Year	Demand Scenario	Annual operations			
		Business Jets	Passenger	Cargo	Total
2038	Low	4,430,250	46,679,400	2,248,400	53,358,100
	Central	4,812,600	55,695,500	2,601,600	63,109,700
	High	4,972,250	63,248,300	2,908,700	71,129,250
2050	Low	5,490,900	65,058,200	2,973,350	73,522,450
	Central	6,156,200	79,478,400	3,739,100	89,373,700
	High	6,375,800	93,682,950	4,564,650	104,623,450

4. CSS SCENARIOS

The CSS consists of 11 scenarios which combine assumptions on supersonic and subsonic demand and technology, and two analysis years (2038 and 2050). The main 9 scenarios share the same technology assumptions for the subsonic and supersonic aircraft ('moderate' and 'mid' respectively), i.e. only the level of demand varies between them. They are presented in Table 5. Scenarios 1, 4 and 7 are without supersonic airliner to help isolate the noise and emissions of SST business jets, which are expected to be lower than those of airliners. Scenarios with unrestricted overland supersonic operations (3, 6 and 9) were assessed for 2050 only since the low-boom aircraft are assumed to enter into service after 2038.

Table 5. CSS main scenarios

Scen. #	Subsonic demand	SST business jet demand	SST airliner demand	Subsonic noise	Subsonic fuel	Subsonic NOx	SST noise, fuel & NOx
1	Low	Low	None	CAEP/13 noise trends moderate scenario (-0.4 EPNdB cumulative per annum)	CAEP/13 fuel trends moderate scenario (-0.96% fuel burn per annum)	CAEP/13 NOx trends moderate scenario (50% of CAEP/7 IE NOx Goal met by 2036)	Mid *(see Table 1)*
2		Low	Low				
3		Low Overland	Low Overland				
4	Central	Mid	None				
5		Mid	Mid				
6		Mid Overland	Mid Overland				
7	High	High	None				
8		High	High				
9		High Overland	High Overland				

The 2 sensitivity scenarios 6a and 6b share the same demand as scenario 6 (subsonic 'central' and supersonic 'mid') but use different technology assumptions. They are presented in Table 6. Scenario 6a assumes that the subsonic fleet performs well environmentally while the supersonic fleet does not; scenario 6b assumes the opposite.

Table 6. CSS sensitivity scenarios

Scen. #	Subsonic demand	SST business jet demand	SST airliner demand	Subsonic noise	Subsonic fuel	Subsonic NOx	SST noise, fuel & NOx
6a	Central	Mid Overland	Mid Overland	CAEP/13 noise trends advanced scenario	CAEP/13 fuel trends IEIR scenario	CAEP/13 NOx trends advanced scenario	High *(see Table 1)*
6b				Technology freeze	Technology freeze	Technology freeze	Low *(see Table 1)*

Data regarding the main business jet and airliner demand indicators can be found in Appendix B for each of the 9 main scenarios and two analysis years.

5. NOISE ASSESSMENT

The following indicators were assessed for each CSS scenario and year, compared to a reference scenario without supersonic operations:

- The percent change in landing and take-off (LTO) noise energy[2] at all airports with SST operations and at a subset of those, with distinction between business jet and airliner SST airports.

- The percent change in day-night average sound level DNL 55 dB contour area at 7 SST airports, grouped into two airport categories ‘airliner’ and ‘business jet’: London Heathrow (EGLL), New York JFK (KJFK), Dubai International (OMDB) and Singapore Changi (WSSS) for SST airliners; Farnborough (EGLF), Teterboro (KTEB) and Le Bourget (LFPB) for SST business jets. Calculations are based on aircraft noise and performance (ANP) developed by DLR for the SST aircraft [5][6][7]. The number of SST movements at airports were adjusted to reflect the assumptions on the cumulative margin to Chapter 14 of SST aircraft presented in Low-boom aircraft are assumed to generate sufficiently low en route noise levels, including at supersonic speed, thereby enabling operations at supersonic speed overland [13].

- Table 1. The DNL calculations assume that supersonic aircraft have the same share of night operations as subsonic aircraft for each airport.

Results for the above indicators can be found in Appendix C. In year 2050, noise energy could increase by up to 9.5% in average at all airports with SST airliner operations and up to 1.8% in average at all airports with SST business jet operations under the scenario with the highest SST demand (scenario #9) compared to a scenario without SST operations. In the same year, the increase in total DNL 55 dB noise contour area at the selected airports could reach up to 40% for the 4 SST airliner airports and 18% for the 3 SST business jet airports under the scenario with the highest SST demand (scenario #9) compared to a scenario without SST operations.

In addition, the single-event landing and take-off SEL 80 dB contour area of the business jet and airliner SST were compared to those of 2024 state-of-the-art subsonic aircraft. For each aircraft the take-off weight used to generate contours is the maximum one (MTOW). The three blue bars represent the three levels of technology (low, mid, high) for the supersonic aircraft as presented in Table 1.B.

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[2] Noise energy is an indicator that combines the certified noise levels of each aircraft type into a single additive number.

Figure 1.A SEL 80 dB contour area of CSS SST aircraft and state-of-the-art subsonic aircraft (airliner)

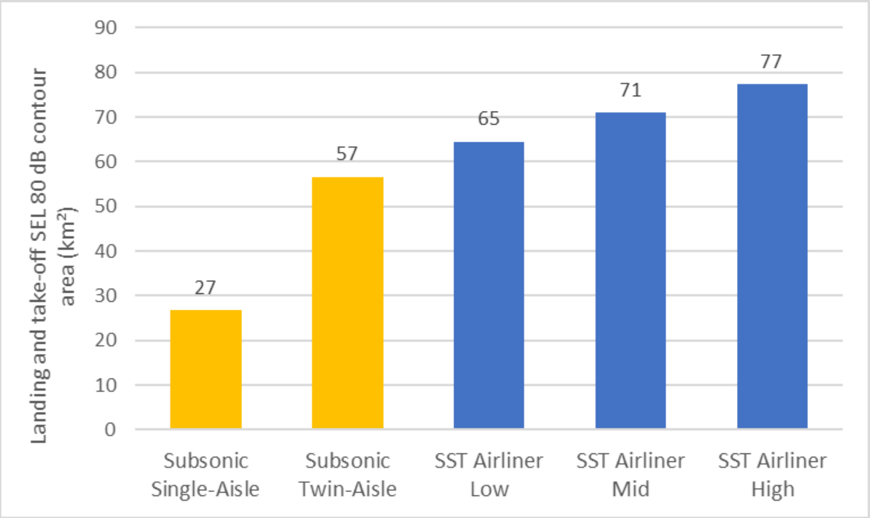
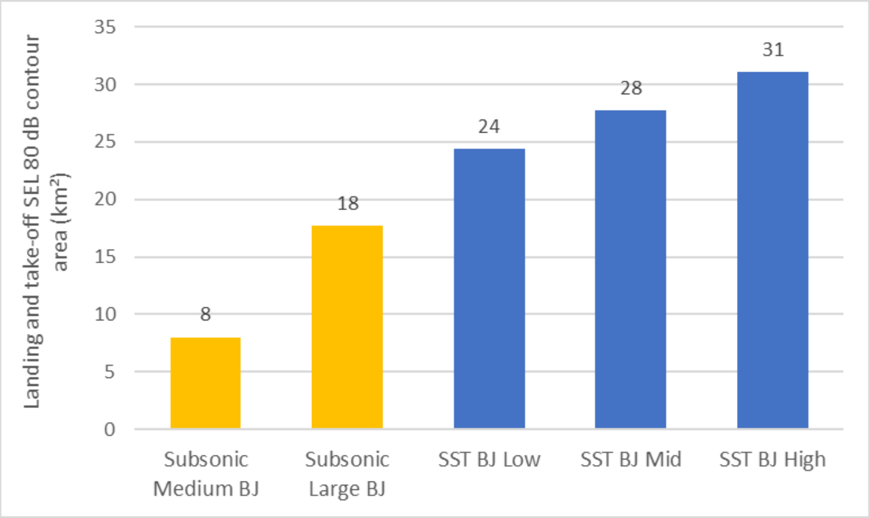


Figure 2.B SEL 80 dB contour area of CSS SST aircraft and state-of-the-art subsonic aircraft (business jet)



6. FUEL BURN AND EMISSIONS ASSESSMENT

The following indicators were assessed for each CSS scenario and year, compared to a reference scenario without supersonic operations:

- The percent change in global (domestic and international) aviation fuel burn or in-flight CO_2 emissions.
- The percent change in global (domestic and international) aviation NOx emissions.

Results for the above indicators can be found in Appendix D. In year 2050, global aviation fuel burn (or in-flight CO_2 emissions) could increase by up to 19% and global aviation NOx emissions could increase by up to 11% under the scenario with the highest SST demand (scenario #9) compared to a scenario without SST operations.

In addition, the average fuel burn per flown kilometre (or seat-kilometre) of the business jet and airliner SST were compared to those of 2024 state-of-the-art subsonic aircraft. The latter were derived from the CAEP models outputs for the CAEP/13 environmental trends. Results are shown in Figure 3 hereunder. The three blue bars represent the three levels of technology (low, mid, high) for the supersonic aircraft as presented in Table 1.B.

Figure 3.A Fuel efficiency of CSS SST aircraft and state-of-the-art subsonic aircraft (airliner)

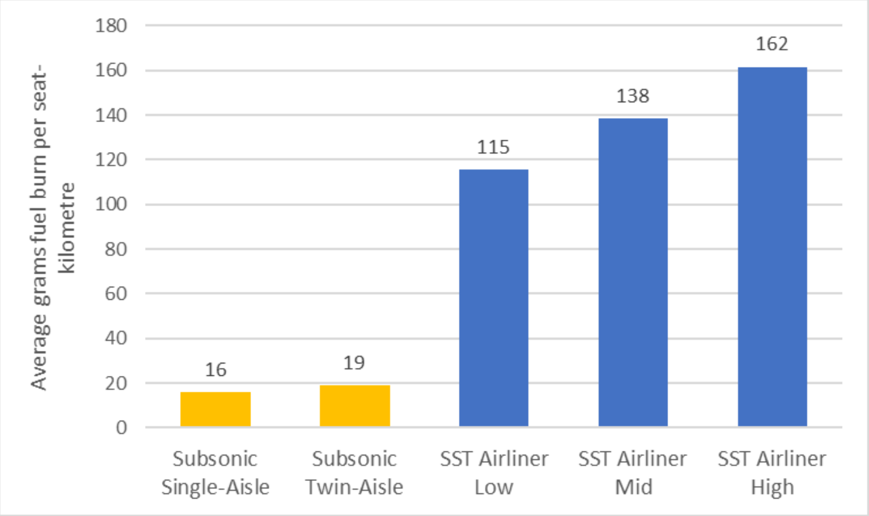


Figure 4.B Fuel efficiency of CSS SST aircraft and state-of-the-art subsonic aircraft (business jet)

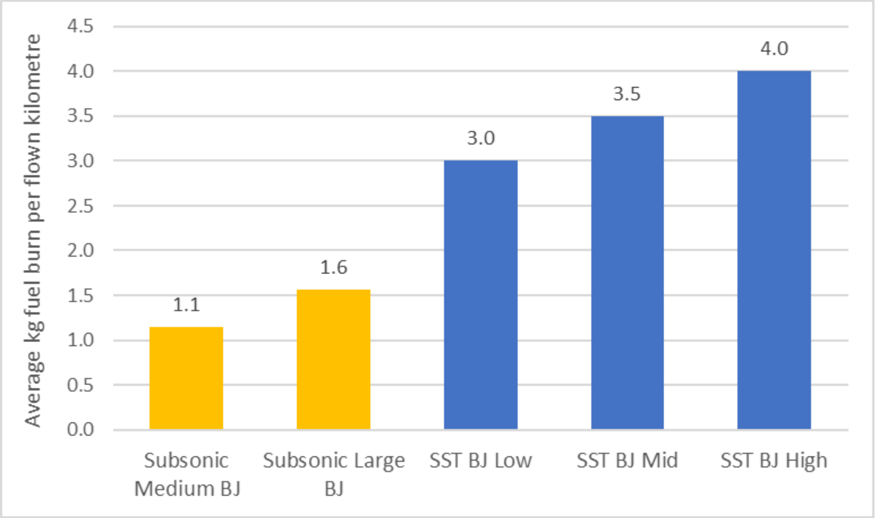


Figure 5 shows the CO_2 emissions (per seat or per flight) of the CSS SST aircraft and 2024 state-of-the-art subsonic aircraft on specific airport pairs (one way): London Heathrow – New York JFK for airliners and Paris Le Bourget – Beijing International for business jets.

Figure 5.A CO_2 emissions of CSS SST aircraft and state-of-the-art subsonic aircraft on route EGLL-KJFK (airliner)

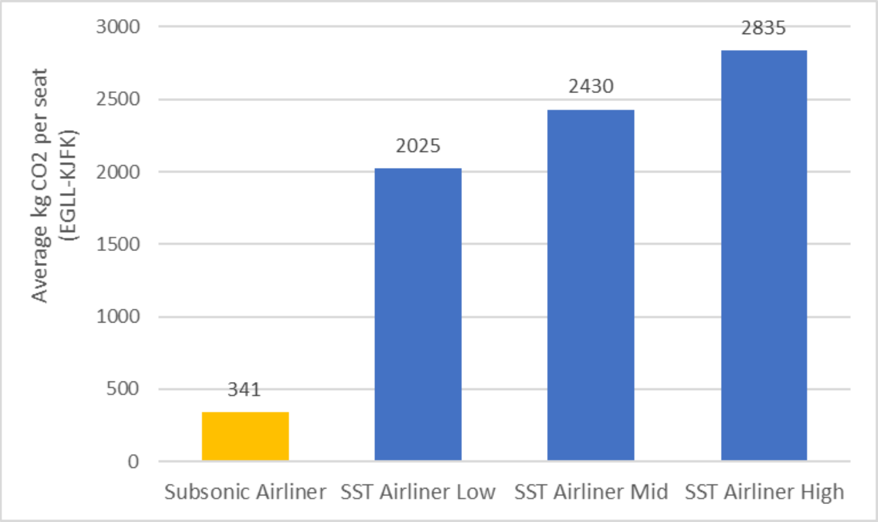
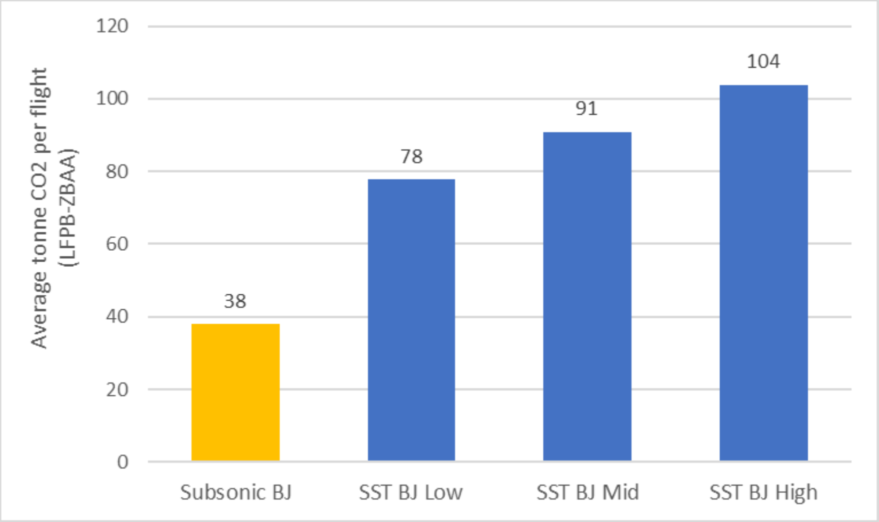


Figure 6.B CO_2 emissions of CSS SST aircraft and state-of-the-art subsonic aircraft on a route LFPB-ZBAA (business jet)



7. MAIN FINDINGS

The future contribution of supersonic aircraft to global aviation's noise and emissions is still uncertain and will depend on the development of this market. The main source of uncertainty is demand (i.e. how many SST aircraft will be in service and how frequently they will operate), followed by the environmental characteristics of SST aircraft (i.e. what will be their noise levels, fuel efficiency and engine emissions).

SST demand and the associated noise and emissions could double if supersonic operations overland are made possible globally by low-boom designs.

Noise and emissions of SST airliners could be an order of magnitude (i.e. about 10 times) greater than those of SST business jets. This is because the number of forecasted operations for SST airliners is larger, as well as their size and weight. The CSS also assumes that SST airliners have a slightly higher maximum cruise speed (Mach 1.7) than business jets (Mach 1.4).

With the range of noise and fuel efficiency characteristics assumed in the CSS, SST business jets could have single landing and take-off SEL 80 dB noise footprints 1.4 to 1.8 times greater than those of 2024 state-of-the-art large subsonic business jets and burn 1.9 to 2.6 times more fuel per flown kilometre. SST airliners could have single landing and take-off SEL 80 dB noise footprints 1.1 to 1.4 times greater than those of 2024 state-of-the-art twin-aisle subsonic aircraft and burn 6.1 to 8.5 times more fuel per passenger-kilometre.

Under a medium demand and technology scenario with unrestricted global overland supersonic operations (CSS scenario #6) and in year 2050:

- SST business jets would represent 3.0% of the business jet fleet, 2.6% of business jet operations and yield a 0.4% reduction in total business jet flight-hours.

- SST airliners would represent 1.3% of the passenger fleet, 1.2% of passenger seat-kilometres and yield a 0.6% reduction in total passenger seat-hours.

- Global aviation fuel burn and in-flight CO_2 emissions would increase by about 8% compared to a scenario without supersonic operations. NOx emissions would increase by about 5%, noting that the uncertainty on emission characteristics of supersonic engines is still high.

- Noise energy at airports with SST operations would increase by about 5% in average. The noise increase at individual airports is directly linked to the local share of SST operations and could therefore vary significantly above and below this average.

- The total 55 dB day-night average sound level (DNL) area at the four hub airports used in the CSS noise contour calculations would increase by 22%; the total DNL 55 dB area at the three business jet airports in the study would increase by 11%.

By 2050 the fuel burn increase linked to supersonic operations could consume a significant part of the fuel burn reduction achieved by fuel efficiency improvements in the subsonic fleet (32% of it under a medium demand and technology scenario). Noise increase could also be non-negligible at a subset of airports representing the bulk of supersonic airliner and business jet operations, thereby consuming a significant part of noise reductions achieved by the subsonic fleet.

8. REFERENCES

[1] ICCAIA, "Connecting the World through Environmentally Responsible Supersonic Flight", ICAO Environmental Report 2022.

[2] EU H2020 SENECA project: https://seneca-project.eu/

[3] EU H2020 MORE&LESS project: https://h2020moreandless.polito.it/

[4] G. Fleming, I. de Lépinay, R. Schaufele, "Environmental Trends in Aviation to 2050", ICAO Environmental Report 2022.

[5] Nöding, Michel und Schuermann, Martin und Bertsch, Lothar und Koch, Marc und Plohr, Martin und Jaron, Robert und Berton, Jeffrey, "Simulation of Landing and Take-off Noise for Supersonic Transport Aircraft at a Conceptual Design Fidelity Level", Aerospace, 9 (1), pages 1-23, MDPI, DOI: 10.3390/aerospace9010009, 2023

[6] L. Bertsch, M. Nöding, R. Jaron and M. Plohr, "Contribution toward single-event and scenario noise assessment of supersonic business jets", Journal of Aircraft, American Institute of Aeronautics and Astronautics (AIAA), DOI: 10.2514/1.C038100

[7] L. Bertsch, F. Lößle, M. Nöding, B. Schäffer and S. Mulani Bertsch, "Uncertainty Quantification of Single Event Noise Predictions for Conceptual Supersonic Transport Aircraft", Journal of Aircraft, American Institute of Aeronautics and Astronautics (AIAA), DOI: 10.2514/1.C038403

[8] R. Speth, S. Eastham, T. Fritz, I. Sanz-Morère, A. Agarwal, P. Prashanth, F. Allroggen, S. Barrett, "Global Environmental Impact of Supersonic Cruise Aircraft in the Stratosphere", NASA/CR-20205009400, 2021

[9] International Civil Aviation Organization, CAEP Supersonic Coordination Group, "Supersonic Exploratory Study Report: Final Report", CAEP/12 WP/39, 2021

[10] International Civil Aviation Organization, CAEP Forecasting and Economic Analysis Support Group, EASA / EUROCONTROL / DLR, "Estimating 2050 SST demand", CAEP/12 MDG-FESG/7 WP/5, 2021

[11] D. Mavris, W. Crossley, J. Tai, "FAA ASCENT Project 010 Aircraft Technology Modeling and Assessment – Final Report", 2023

[12] Deutsches Zentrum für Luft- und Raumfahrt, DLR Institut für Lufttransportsysteme, "DEPA 2050 – DLR-EASA Prospective Aviation Study 2050", 2021

[13] D. Maglieri, P. Bobbitt, K. Plotkin, K. Shepherd, P. Coen, D. Richwine, "Sonic boom – Six decades of research", NASA/SP-2014-622, 2014

[14] International Civil Aviation Organization, "Annex 16 to the Convention on International Civil Aviation, Volume I, Aircraft Noise", Amendment 14, 2023

[15] C. Weit, J. Wen, A. Anand, H. Kaur, "Overall Air Transport System Vehicle Scenarios (OASyS) Deliverable 4.1 – Forecasting Data & Final Results Report", Clean Sky 2 Joint Undertaking, 2020

[16] D. Marsh, "himach: Find Routes for Supersonic Aircraft", doi:10.32614/CRAN.package.himach <https://doi.org/10.32614/CRAN.package.himach>, R package version 1.0.0, <https://CRAN.R-project.org/package=himach>, 2025

APPENDIX A

SST DEMAND DATA REVIEW

Study	Year	Scenario	SST Business Jet (oversea only)			SST Airliner (oversea only)		SST Airliner (oversea + overland)	
			# of aircraft	# of routes 1-way	Annual operations 1-way	# of routes 1-way	Annual operations 1-way	# of routes 1-way	Annual operations 1-way
MIT [8]	2035	Low	n/a			n/a		n/a	334,000
		Mid							670,000
		High							1,344,000
CAEP/12 Exploratory Study [9]	2038	Low	200	3,955	18,326	406	37,934	n/a	
		Mid	350	5,617	44,201	1,000	360,989		
		High	500	6,730	79,953	1,908	993,794		
EUROCONTROL / EASA / DLR [10]	2038	Low	200	3,955	20,000	80	21,314	n/a	
		Mid	350	5,617	47,250	472	189,791		
		High	500	6,730	85,000	844	523,748		
	2050	Low	440	3,955	44,000	156	48,173	224	130,229
		Mid	770	5,617	103,950	674	337,295	1,077	989,915
		High	1100	6,730	187,000	1,160	934,463	1,840	2,767,352
FAA ASCENT Project 010 [11]	2050	n/a	n/a			1,048	2,354,272	n/a	
Clean Sky 2 OASyS [15]	2050	Low		3,473	63,145	256	36,508	n/a	
		High		9,518	256,595	756	119,554		
DLR DEPA [12]	2050	n/a	n/a			358	84,797	419	220,815
SENECA [2]	2050	Mid	760	5,980	86,008	492	193,700	n/a	
		High	950	5,994	113,256	1,684	850,980		
Georgia Tech / NASA ULI	2050	n/a	n/a			392	523,946	n/a	

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APPENDIX B

DEMAND ASSESSMENT

		Subsonic Fleet				SST Business Jet (BJ)					SST Airliner (PAX)						Total				
Year	CSS Scenario	Demand scenario	Total ops 1-way (millions)	BJ ops 1-way (millions)	Airliner seat-km	Demand scenario	# of aircraft	# of routes 1-way	# of airports	Ops 1-way	Demand scenario	# of aircraft	# of routes 1-way	# of airports	Ops 1-way	Seat-km	Delta* ops	Share of SST ops (BJ)	Delta* flight-hours (BJ)	Share of SST seat-km (PAX)	Delta* seat-hours (PAX)
2038	1	Low	53.1	4.43	1.60E+13	Low	200	3955	354	20,000	None	0	0	0	0	0	0.04%	0.5%	-0.1%	0.0%	0.0%
	2	Low	53.1	4.43	1.60E+13	Low	200	3955	354	20,000	Low	28	80	36	21,314	9.95E+09	0.1%	0.5%	-0.1%	0.1%	-0.02%
	4	Central	62.9	4.81	1.92E+13	Mid	350	5617	364	47,250	None	0	0	0	0	0	0.1%	1.0%	-0.2%	0.0%	0.0%
	5	Central	62.8	4.81	1.91E+13	Mid	350	5617	364	47,250	Mid	268	472	108	189,791	9.37E+10	0.3%	1.0%	-0.2%	0.5%	-0.2%
	7	High	70.9	4.97	2.19E+13	High	500	6730	368	85,000	None	0	0	0	0	0	0.1%	1.7%	-0.3%	0.0%	0.0%
	8	High	70.8	4.97	2.16E+13	High	500	6730	368	85,000	High	742	844	162	523,748	2.59E+11	0.7%	1.7%	-0.3%	1.2%	-0.4%
2050	1	Low	73.3	5.49	2.45E+13	Low	440	3955	354	44,000	None	0	0	0	0	0	0.1%	0.8%	-0.1%	0.0%	0.0%
	2	Low	73.3	5.49	2.45E+13	Low	440	3955	354	44,000	Low	64	156	60	48,173	2.25E+10	0.1%	0.8%	-0.1%	0.1%	-0.04%
	3	Low	73.2	5.49	2.45E+13	Low OL	680	3955	354	68,000	Low OL	133	448	107	130,229	4.87E+10	0.2%	1.2%	-0.2%	0.2%	-0.1%
	4	Central	89.1	6.16	3.02E+13	Mid	770	5617	364	103,950	None	0	0	0	0	0	0.1%	1.7%	-0.3%	0.0%	0.0%
	5	Central	89.0	6.16	3.00E+13	Mid	770	5617	364	103,950	Mid	468	674	138	337,295	1.63E+11	0.4%	1.7%	-0.3%	0.5%	-0.2%
	6	Central	88.9	6.16	3.00E+13	Mid OL	1190	5617	364	160,650	Mid OL	1037	2154	251	989,915	3.80E+11	1.0%	2.6%	-0.4%	1.2%	-0.6%
	7	High	104.3	6.38	3.59E+13	High	1100	6730	368	187,000	None	0	0	0	0	0	0.2%	2.9%	-0.5%	0.0%	0.0%
	8	High	104.1	6.38	3.54E+13	High	1100	6730	368	187,000	High	1303	1160	206	934,463	4.53E+11	0.9%	2.9%	-0.5%	1.3%	-0.4%
	9	High	103.7	6.38	3.54E+13	High OL	1700	6730	368	289,000	High OL	2912	3680	361	2,767,352	1.07E+12	2.4%	4.5%	-0.8%	2.9%	-1.3%

BJ = business jet

PAX = airliner

Ops = operations

OL = overland

(*) Deltas are with reference to a demand scenario without supersonic traffic

Note: the lines on the following maps show the shortest (great circle) trajectory between origin and destination airports, and not the actual trajectory expected to be flown by the aircraft. Stopovers are not represented.

Figure B1. SST airliner 2050 route network without overland operations (top to bottom: low, mid, high demand)

Figure B2. SST airliner 2050 route network with overland operations (top to bottom: low, mid, high demand)

Figure B3. SST business jet 2050 route network (top to bottom: low, mid, high demand)

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APPENDIX C

NOISE ASSESSMENT

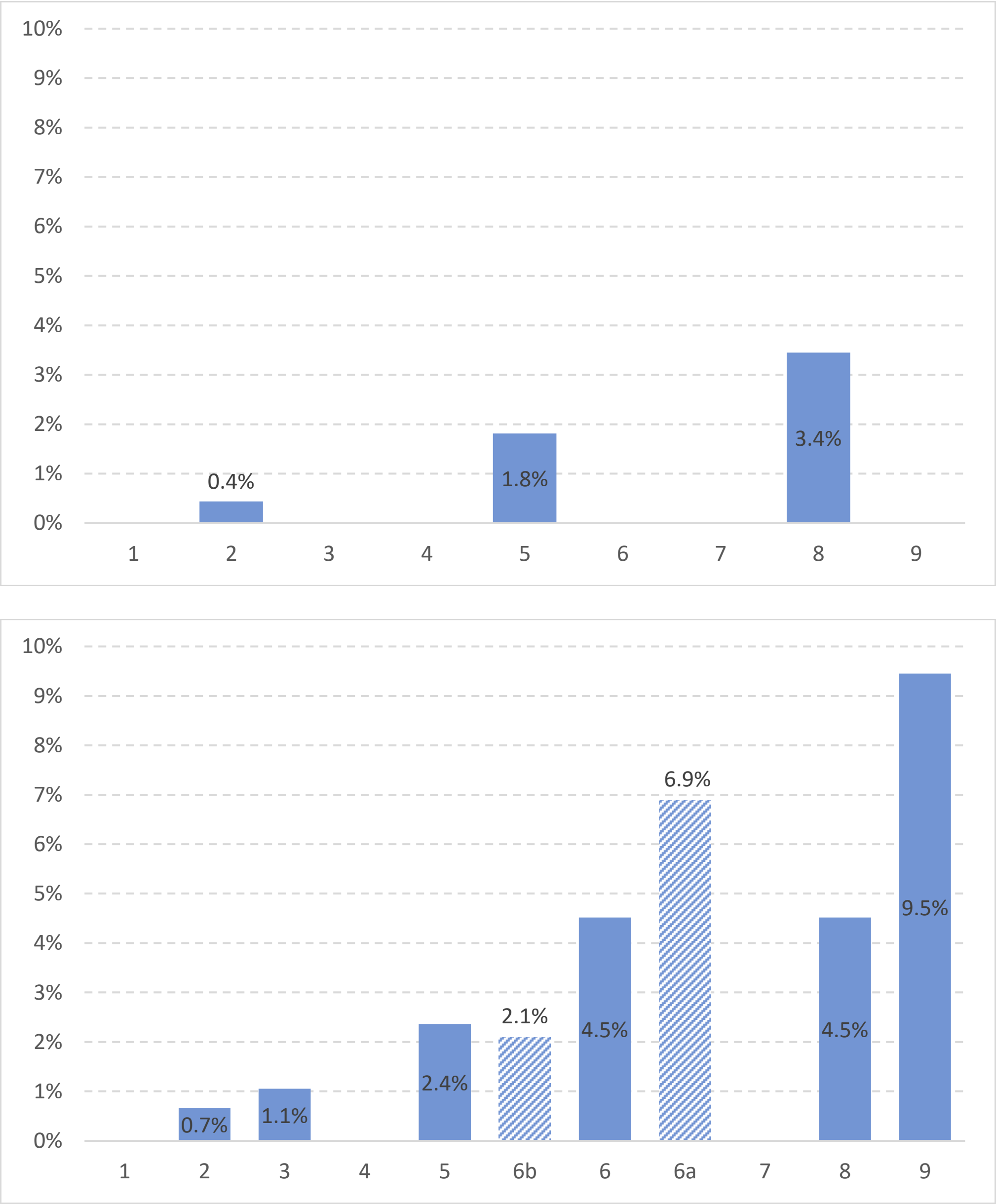
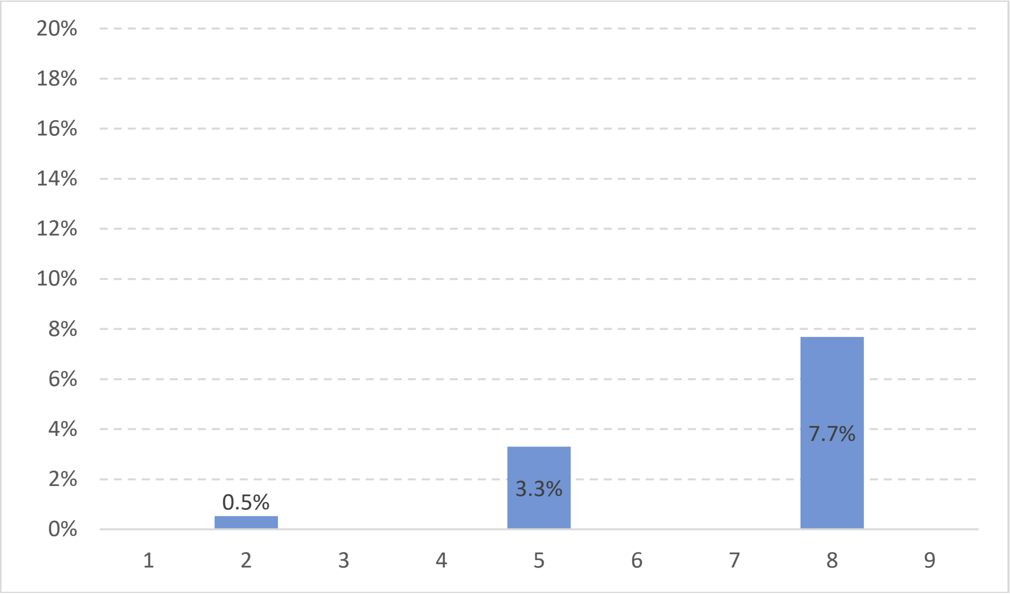


Figure C1. Average change in noise energy at all airports with SST airliner operations by scenario (2038 top, 2050 bottom)



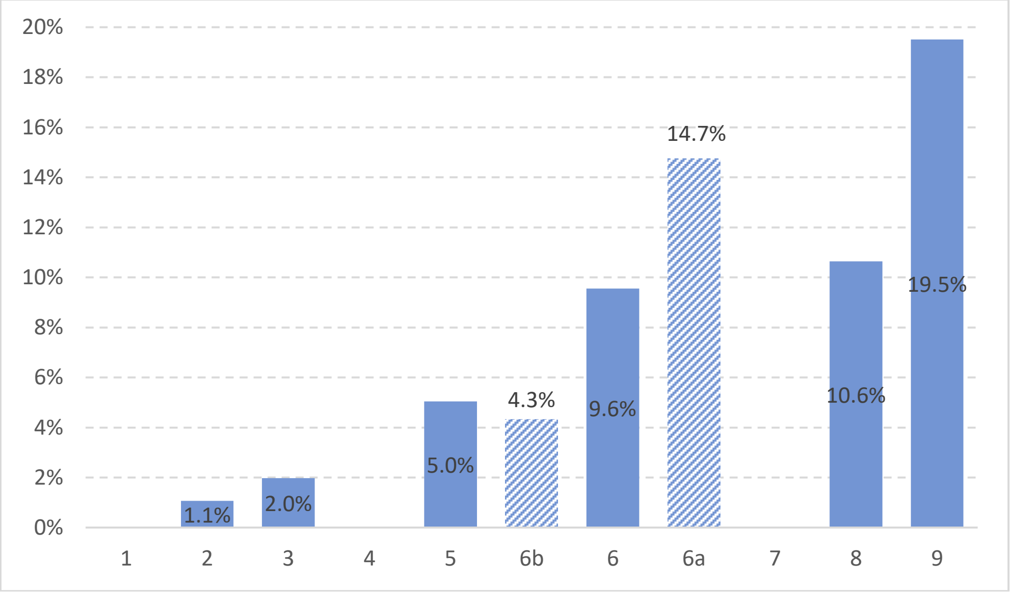


Figure C2. Average change in noise energy at top 20 airports with largest SST airliner operations by scenario (2038 top, 2050 bottom)

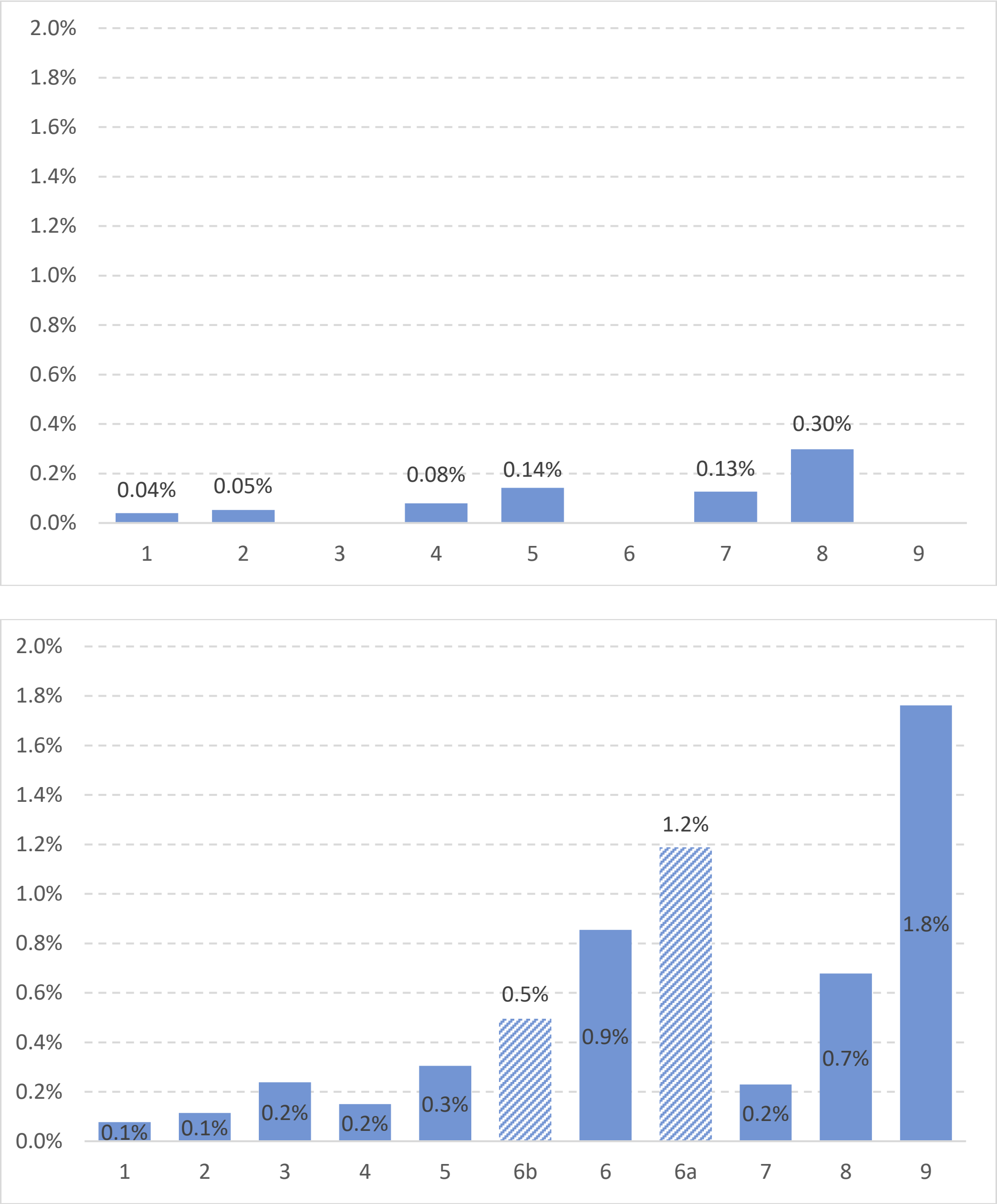


Figure C3. Average change in noise energy at all airports with SST business jet operations[3] by scenario (2038 top, 2050 bottom)

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[3] This excludes airports with operations by both SST business jets and SST airliners.

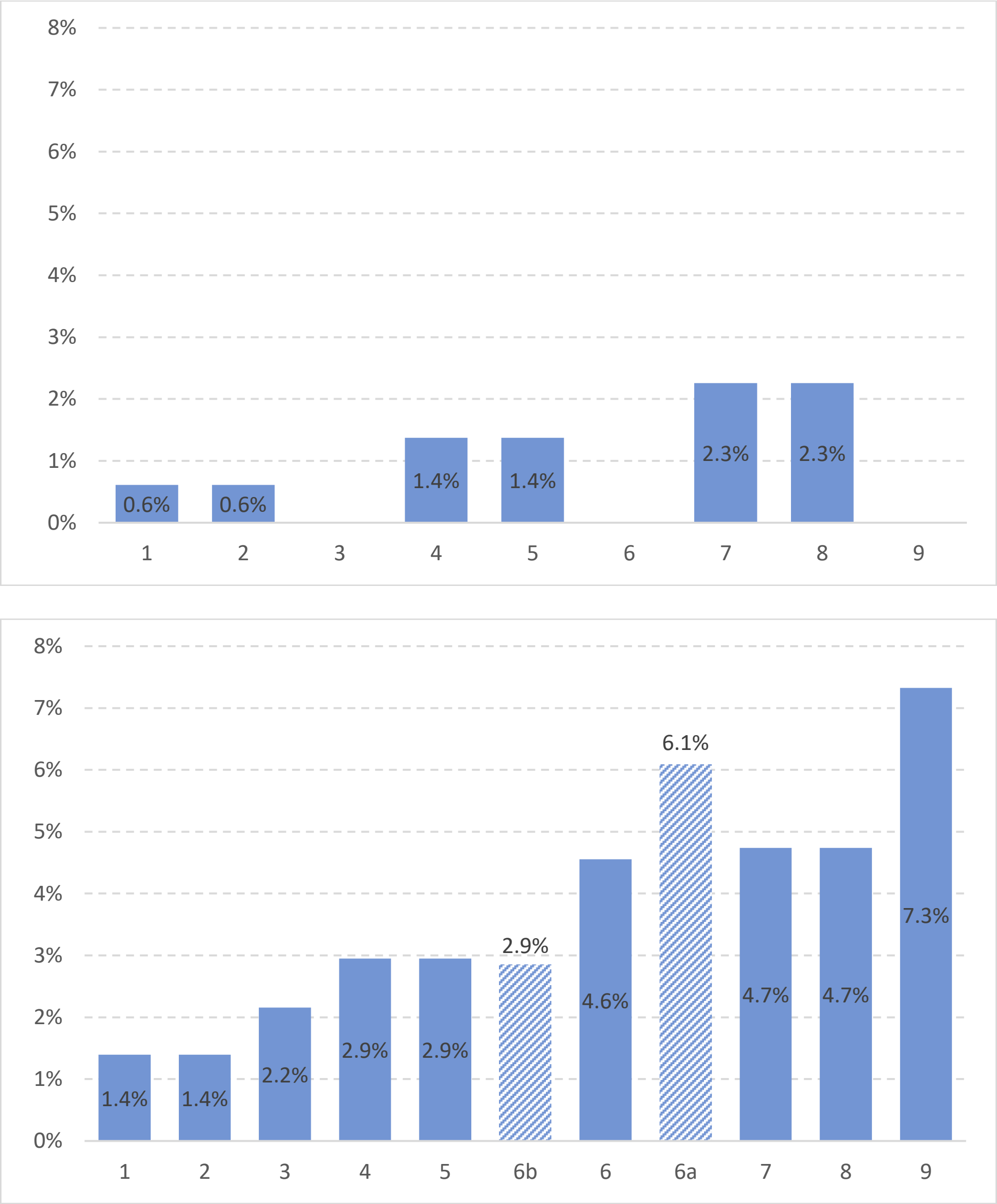

Figure C4. Average change in noise energy at top 20 airports with largest SST business jet operations[4] by scenario (2038 top, 2050 bottom)

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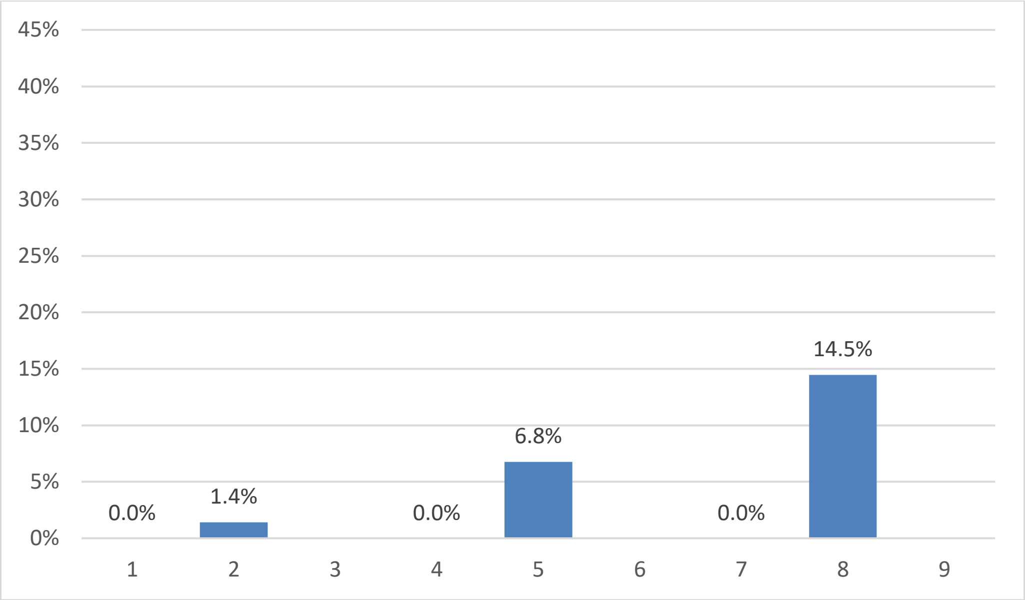
[4] This excludes airports with operations by both SST business jets and SST airliners.



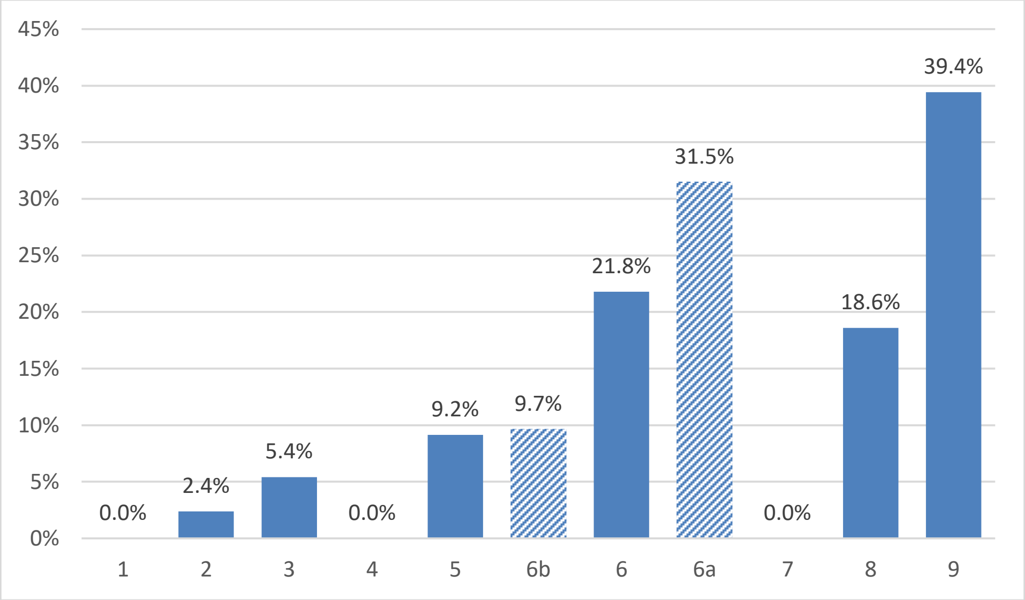
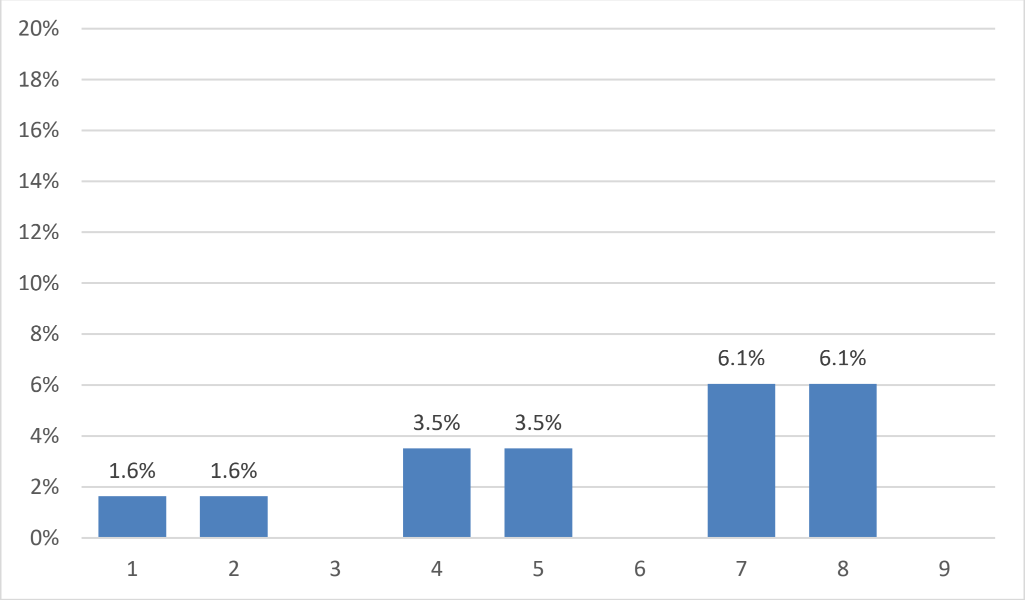


Figure C5. Change in total DNL 55 dB area at four SST airliner airports EGLL, KJFK, OMDB and WSSS by scenario (2038 top, 2050 bottom)



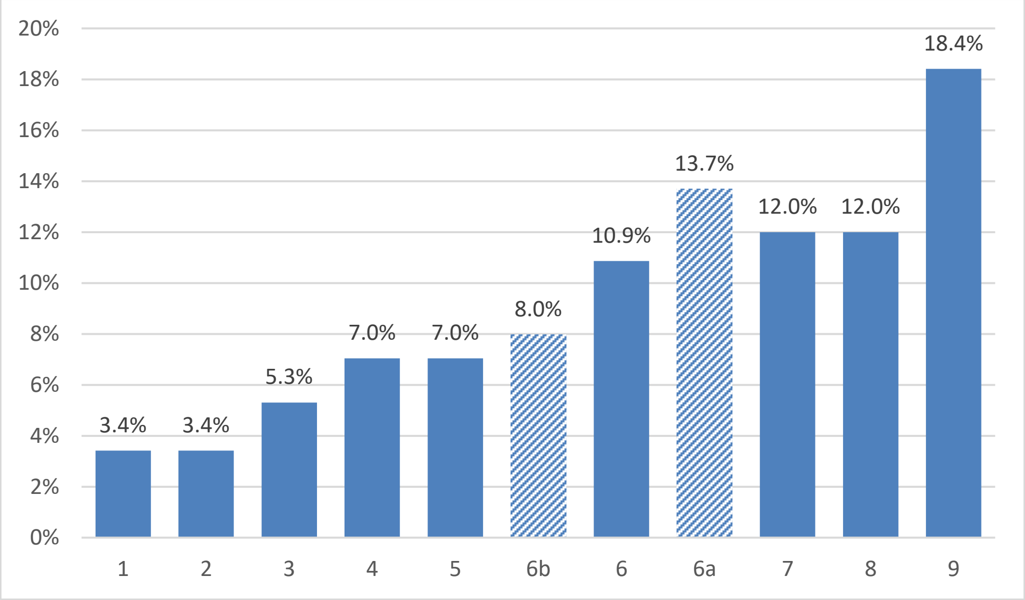


Figure C6. Change in total DNL 55 dB area at three SST business jet airports EGLF, KTEB and LFPB by scenario (2038 top, 2050 bottom)

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APPENDIX D

FUEL BURN AND EMISSIONS ASSESSMENT

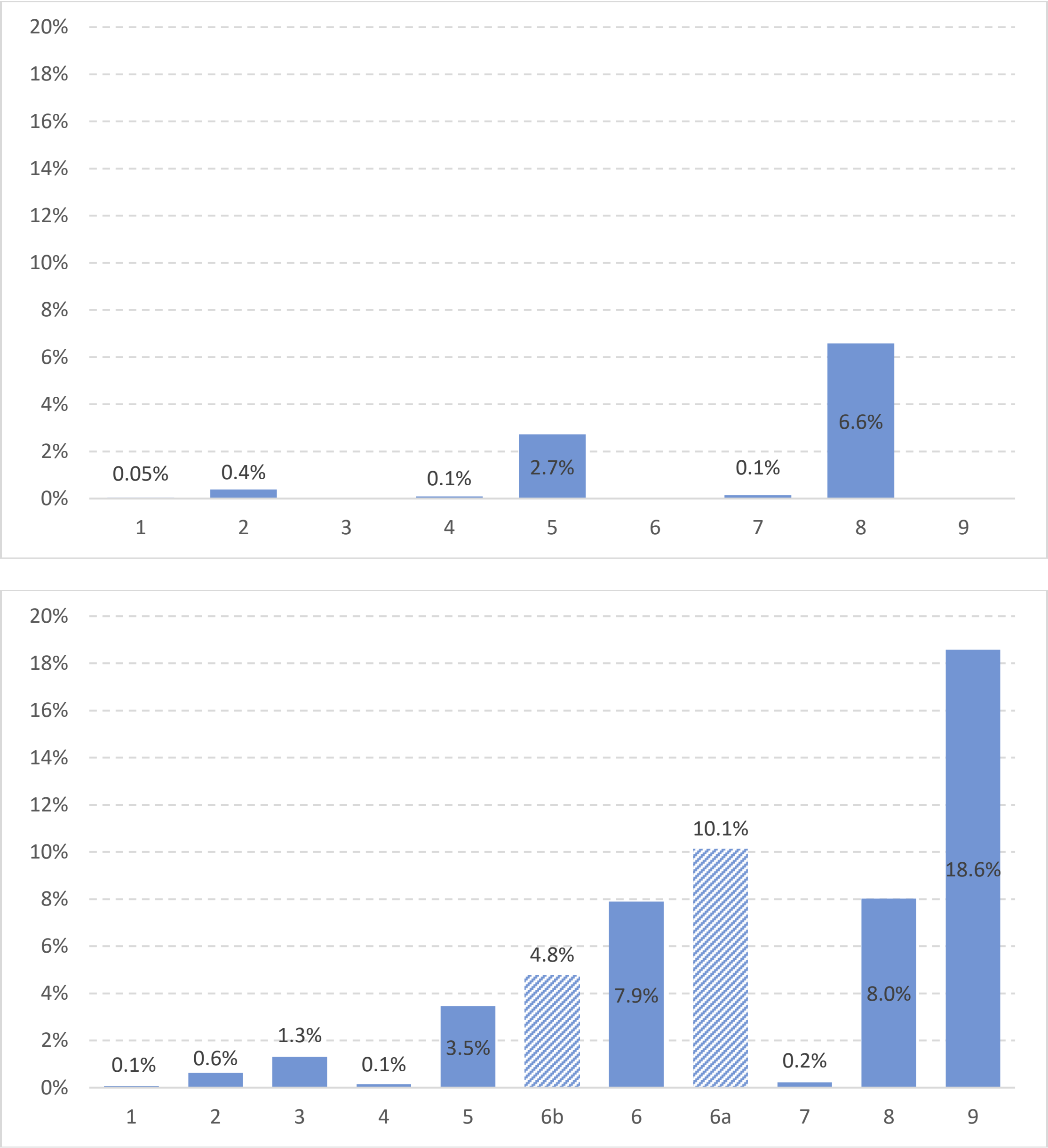

Figure D1. Change in global (domestic and international) aviation fuel burn or in-flight CO_2 emissions by scenario (2038 top, 2050 bottom)

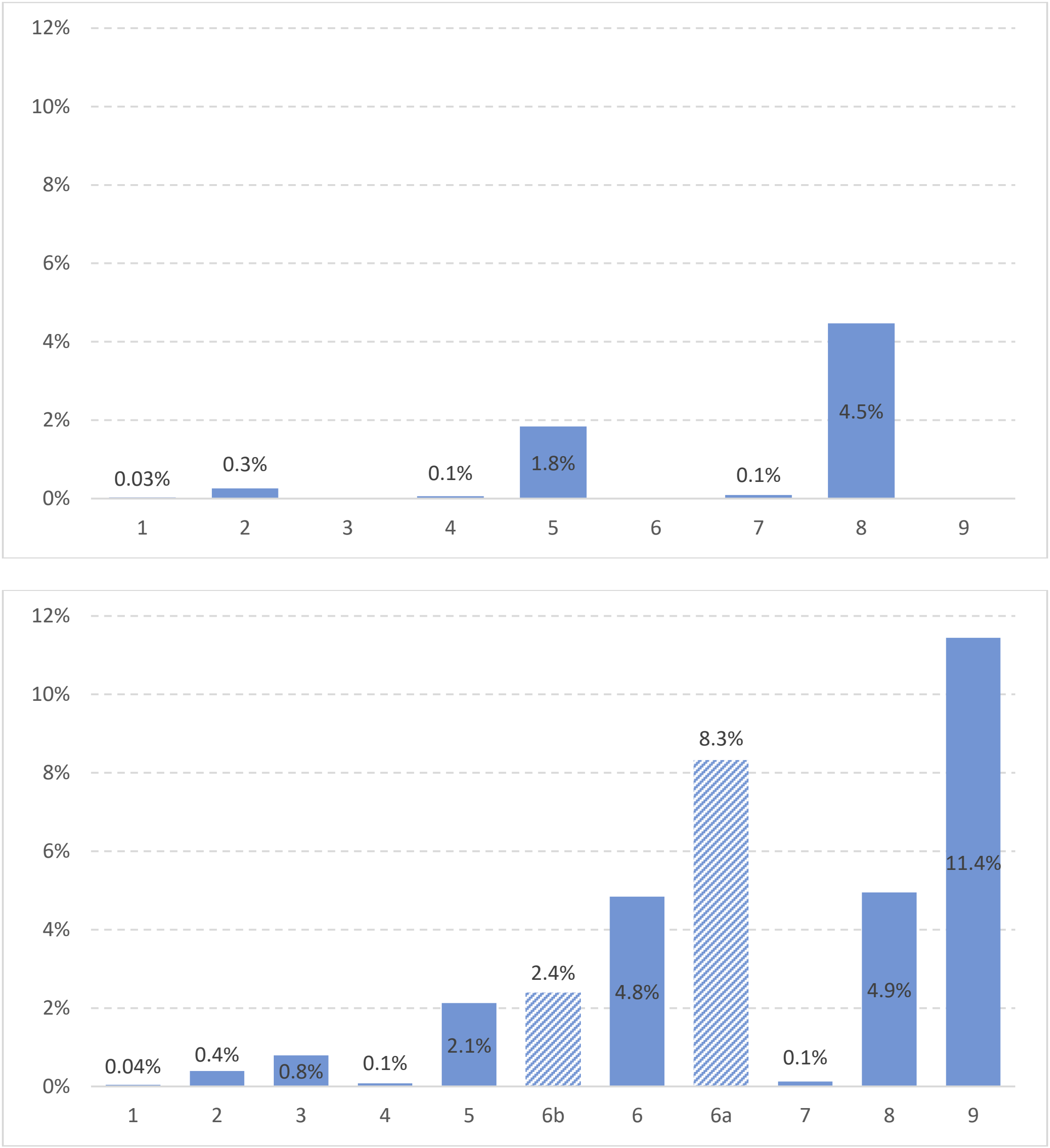

Figure D2. Change in global (domestic and international) aviation NOx emissions by scenario (2038 top, 2050 bottom)

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