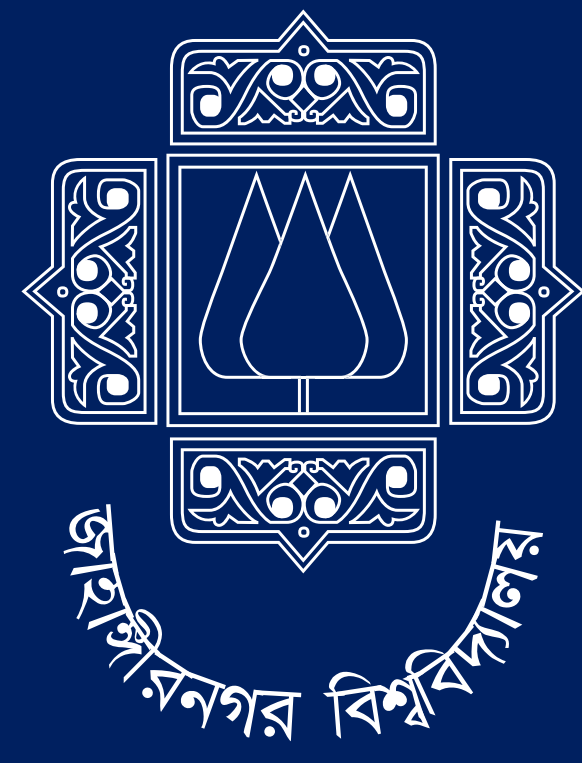




Quantification of Aircraft Landing and Take-Off (LTO) Emissions and Environmental Implications at HSIA, Dhaka

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INTRODUCTION

Airports are recognized as localized emission hotspots due to concentrated aircraft activity, especially during the Landing and Take-Off (LTO) cycle, which occurs below 1,000 m altitude and directly affects surrounding urban air quality. Pollutants such as NO_x, CO, HC and PM_{2.5} emitted during LTO operations contribute to photochemical smog formation, respiratory health impacts and environmental degradation.

Hazrat Shahjalal International Airport (HSIA) handles the majority of Bangladesh's domestic and international air traffic and is surrounded by rapidly urbanizing residential and commercial zones. Despite this, detailed aircraft emission inventories for HSIA remain scarce in the scientific literature.

This study aims to quantify aircraft LTO emissions at HSIA using a simplified, transparent and reproducible methodology suitable for data-limited environments and to identify key aircraft categories and LTO phases responsible for pollutant emissions.

DATA SOURCES

- ICAO Airport Air Quality Manual
- ICAO Engine Emissions Databank
- European Union Aviation Safety Agency online
- Publicly available airline schedules and aircraft operation data (Flightradar24)

STUDY AREA

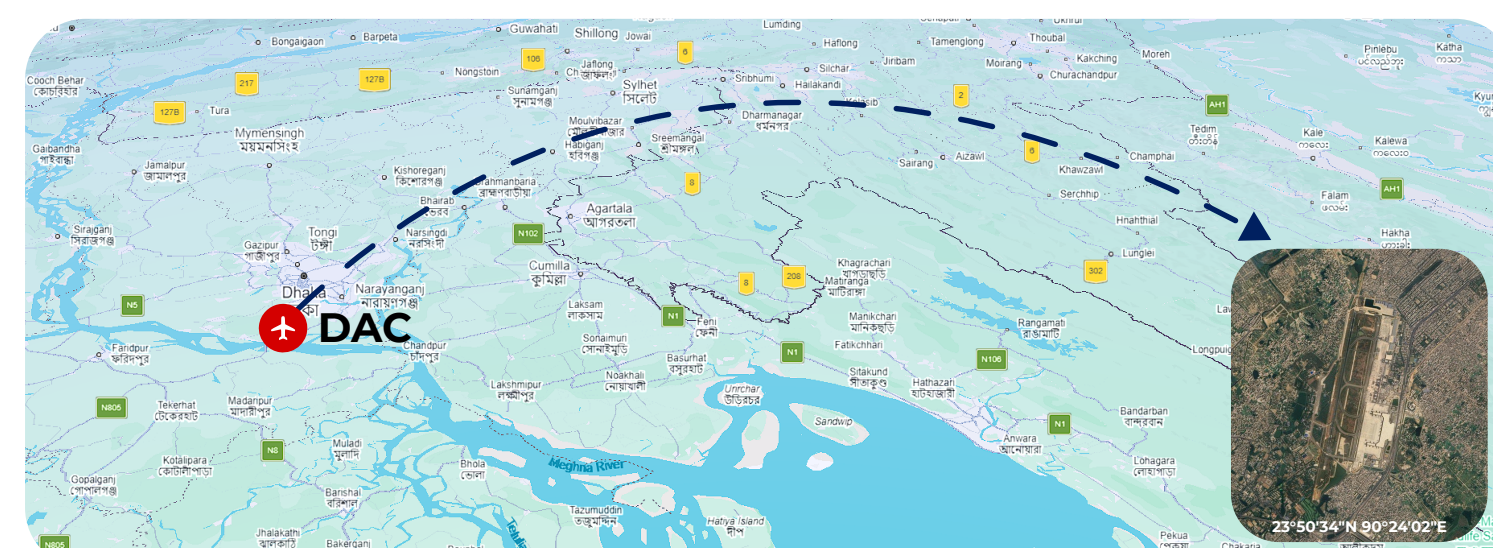


Figure 1: Location of Hazrat Shahjalal International Airport (HSIA), Dhaka, Bangladesh

METHODOLOGY & DATA

LTO CYCLE

The Landing and Take-Off (LTO) cycle is defined according to ICAO guidelines and consists of four operational modes: taxi/idle, take-off, climb-out and approach. Emissions generated during these phases occur at low altitudes and have direct impacts on local air quality.

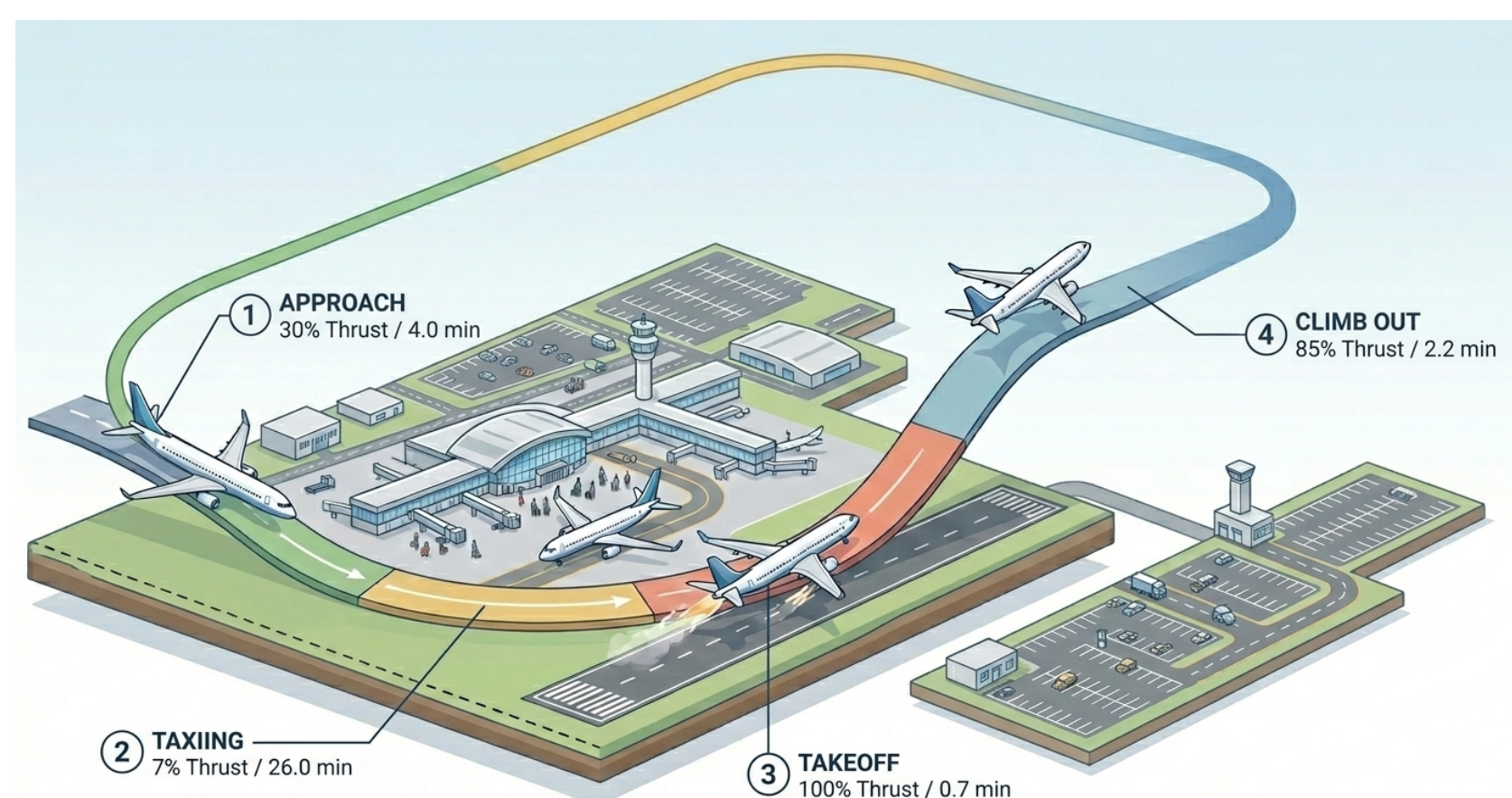


Figure 2: Standard ICAO LTO cycle and time-in-mode assumptions.

EMISSION ESTIMATION METHOD

LTO cycle covers two aircraft operations, i.e., landing (approach, landing, and taxi-in to the gate) and take-off (taxi- out, onto the runway, take-off and climb-out). The aircraft emissions for the recent operational years (post-COVID recovery phase) were quantified NO_x, HC, CO and PM at HSIA. The emissions can be estimated using the method of the IPCC, which calculates emissions in terms of the collective activity data multiplied by the consistent average emission factors.

$$E_{i,j,t} = LTO_{i,t} \cdot EF_j$$

where,

$E_{i,j,t}$: the annual emissions of air pollutant j at airport i for year t ,
 $LTO_{i,t}$: the total number of LTO cycles conducted at airport i for year t , and
 EF_j : the general emission factor of air pollutant j per LTO cycle (kg/ LTO).

AIR TRAFFIC TREND

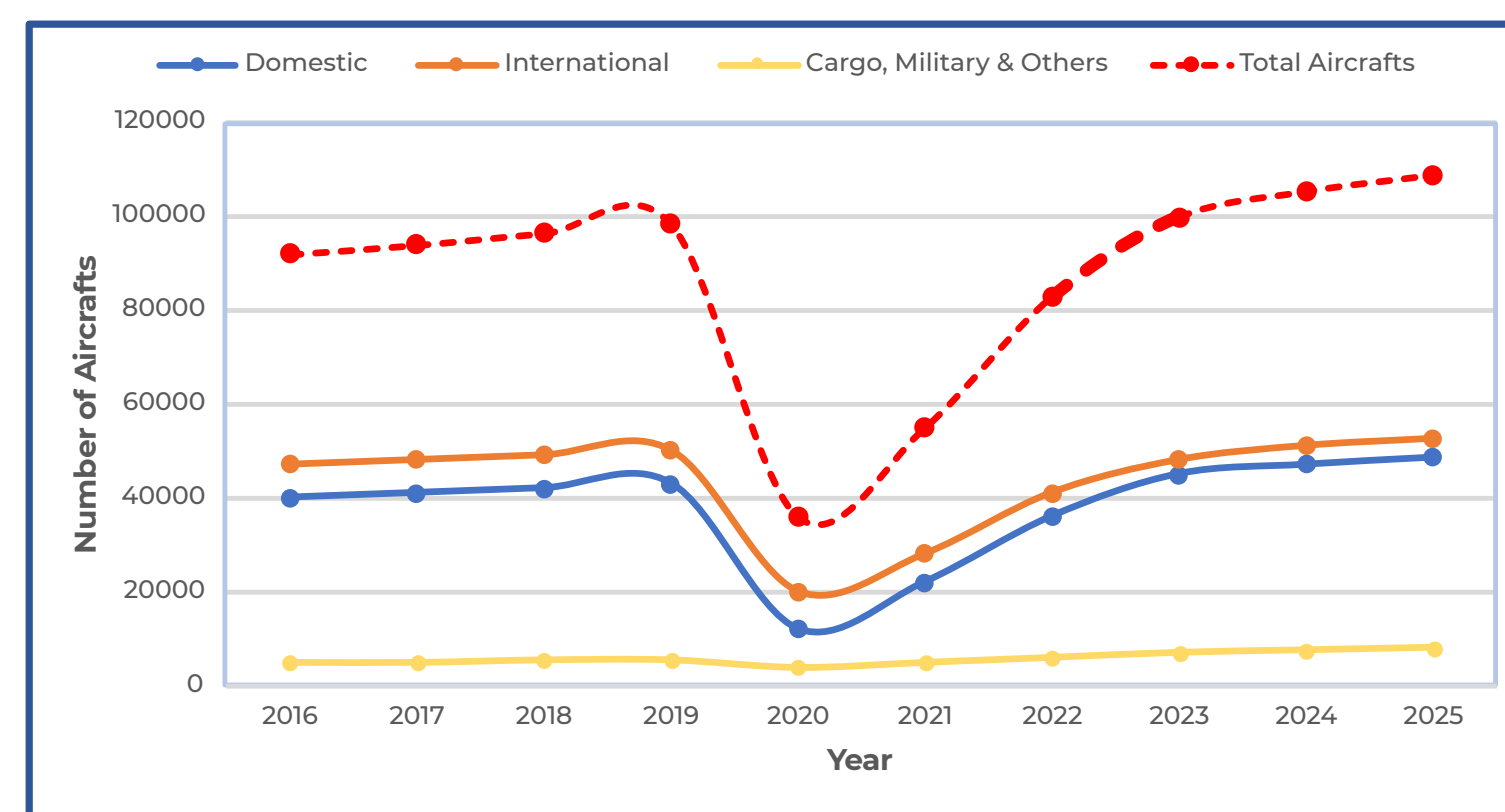


Figure 3: Annual aircraft movements at HSIA (2016-2025)

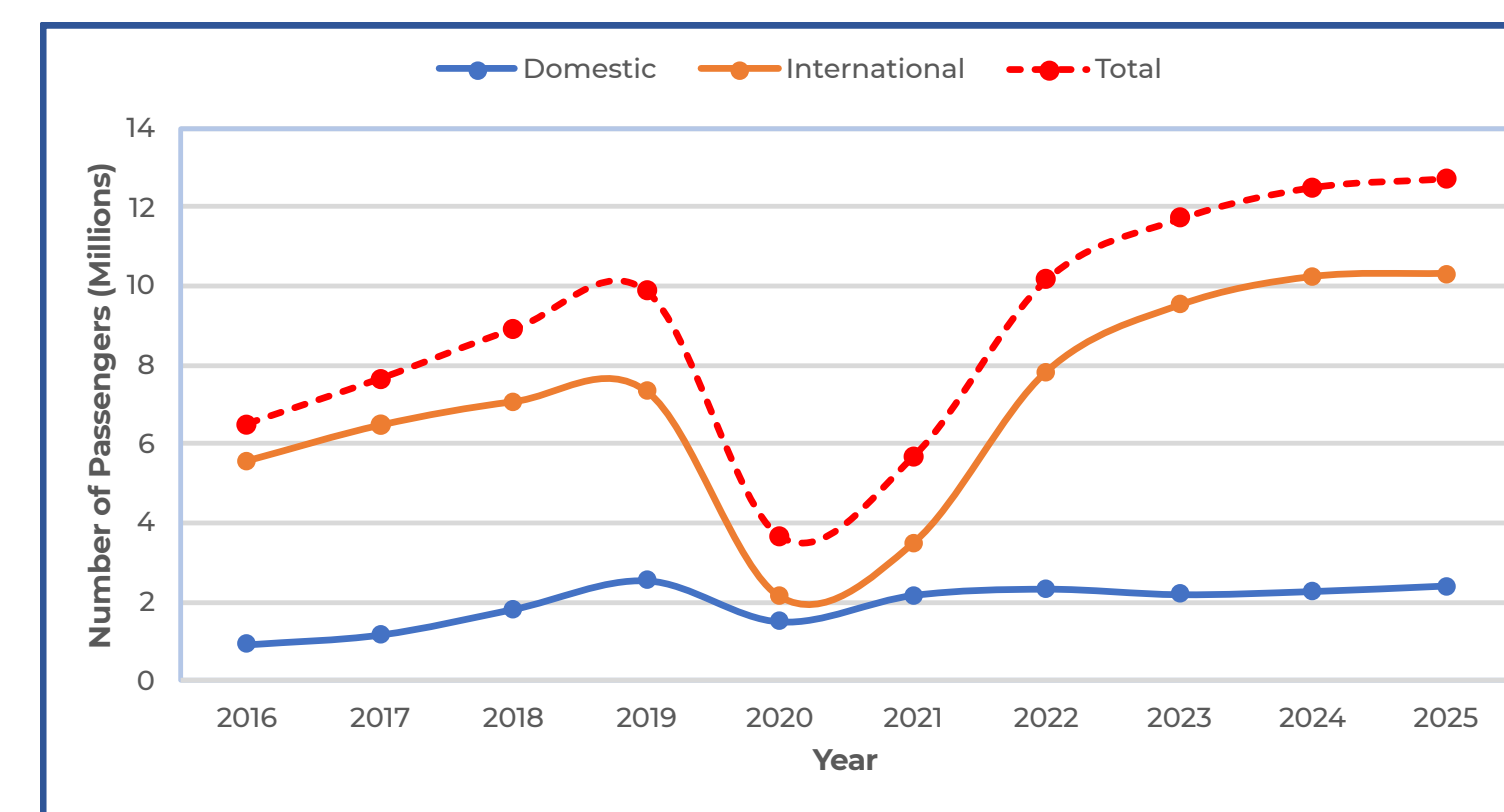


Figure 4: Annual passengers movements at HSIA (2016-2025)

RESULTS & DISCUSSION

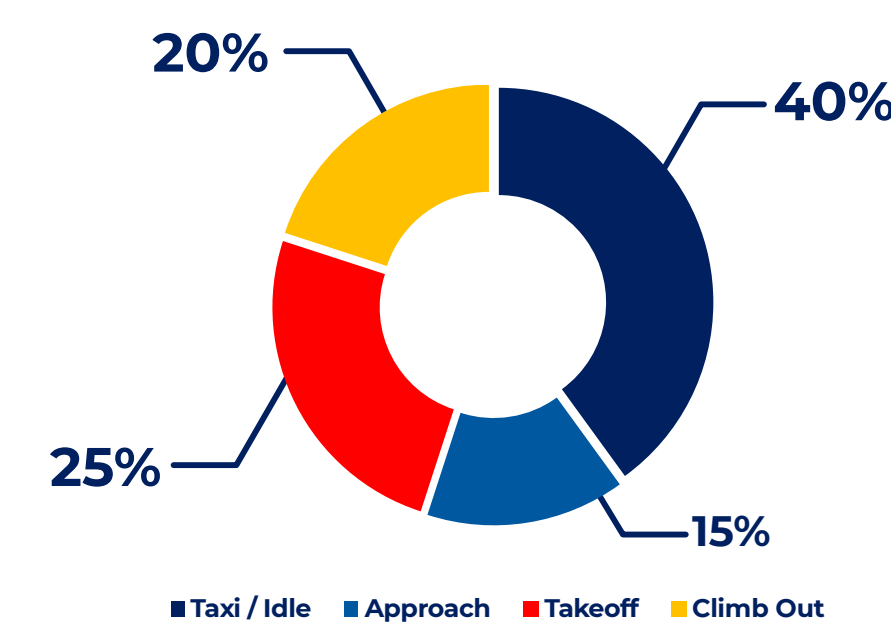


Figure 5: Percentage contribution of LTO modes to total aircraft emissions.

Taxi/idle and take-off phases account for the largest share of emissions, highlighting the importance of ground operations in emission mitigation strategies.

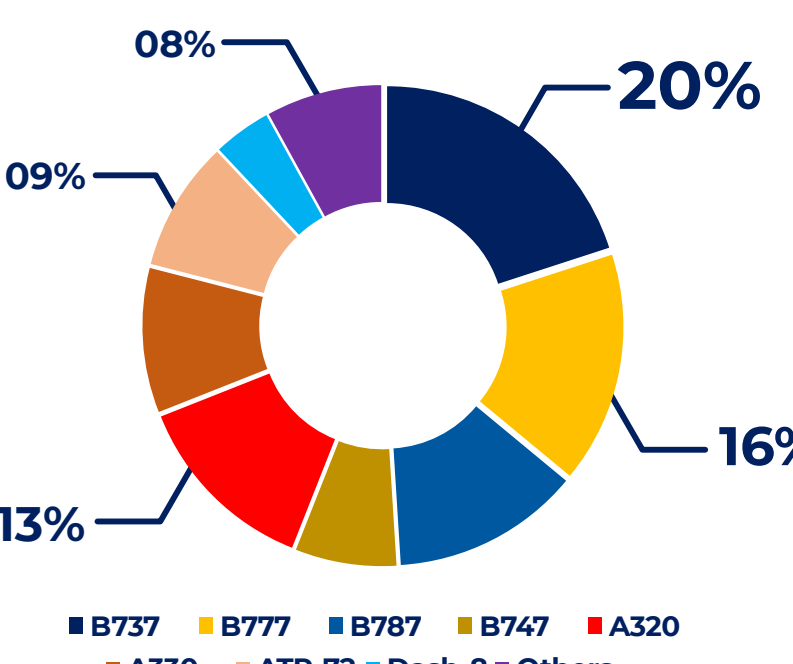


Figure 6: Distribution of dominant aircraft types performing LTO operations at HSIA.

Narrow-body aircraft (B737 and A320 family) dominate LTO operations, followed by wide-body aircraft such as B777, B787, and A330. Turboprop aircraft (ATR72 and Dash-8) contribute significantly due to high-frequency domestic operations.

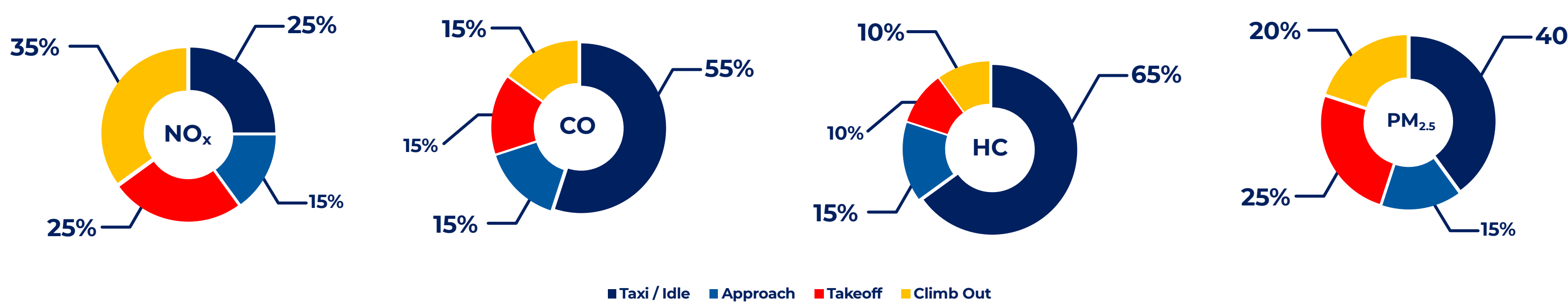


Figure 7: The distributions of LTO emissions.

ESTIMATED ANNUAL EMISSIONS

Aircraft Model	Engine Type	Annual LTO (Est.)	NO _x (t/y)	CO (t/y)	HC (t/y)	PM _{2.5} (t/y)
B777	GE90-115B	5148	213.11	85.5	6.71	0.92
B787-8/9	GENx-1B	3068	88.2	31.7	0.74	0.36
B737	CFM56-7B	7280	90	51	5.2	0.9
A320/A321Ceo	CFM56-5B	5460	54	44.5	1.8	0.9
A320Neo /A321Neo	LEAP-1A	2912	17.3 /31.3	20.3	0.3	0.1
A330-300/200	Trent 772B-60	3068	109	49.7	3.92	0.6
B747	CF6 / GENx-2B	1456	66.3	38.8	3.6	0.34
ATR 72-500	PW127F	6916	13	16.2	0.8	0.4
ATR 72-600	PW127M	13,156	40	46	3.3	0.8
Dash-8	PW150A	5252	8.1	12	0.2	0.3

Table 1: Values represent estimated average annual emissions based on recent operational activity.

The results show that wide-body aircraft (B777/B747) contribute the majority of NO_x emissions, while narrow-body (B737/A320neo) and turboprop aircraft (ATR/Dash-8) contribute substantially to CO and HC emissions due to high LTO frequencies.

DISCUSSION

The transition from the CFM56-5B (A320ceo) to the LEAP-1A (A320neo) represents the most significant "Green" shift at HSIA. Despite similar mission profiles, the LEAP-1A's advanced TAPS (Twin Annular Pre-mixing Swirler) combustor allows for lower peak flame temperatures, directly reducing NO_x formation during the take-off and climb phases.

While engines like the GE90-115B (B777) are highly advanced, their sheer size and fuel flow mean that a single LTO cycle contributes significantly more NO_x than ten domestic ATR cycles combined. This underscores the need for "Green Departure" procedures for long-haul carriers.

CONCLUSION

This study provides a critical empirical baseline for the aviation-induced atmospheric load at Hazrat Shahjalal International Airport (HSIA). By analyzing 10 dominant aircraft types—ranging from high-frequency regional turboprops to heavy long-haul wide-bodies. The standardized 26-minute taxi duration at HSIA is a primary driver for elevated CO and HC levels. These "Incomplete Combustion" pollutants are concentrated at ground level, directly impacting the health of the surrounding residential communities in Uttara, Dakshinkhan, Kurmitola.

REFERENCES

- International Civil Aviation Organization (ICAO). (2020). Airport Air Quality Manual (Doc 9889), 2nd Ed.
- ICAO Aircraft Engine Emissions Databank (EDB). (2024). European Union Aviation Safety Agency (EASA).
- FlightRadar24 & CAAB Operational Logs. (2022-2025). Fleet frequency data for HSIA.

LIMITATIONS & FUTURE WORK

- Simplified emission factors used
- Future work: Dispersion modeling (AERMOD), On-site monitoring and Scenario-Based Mitigation Analysis Using Machine Learning.