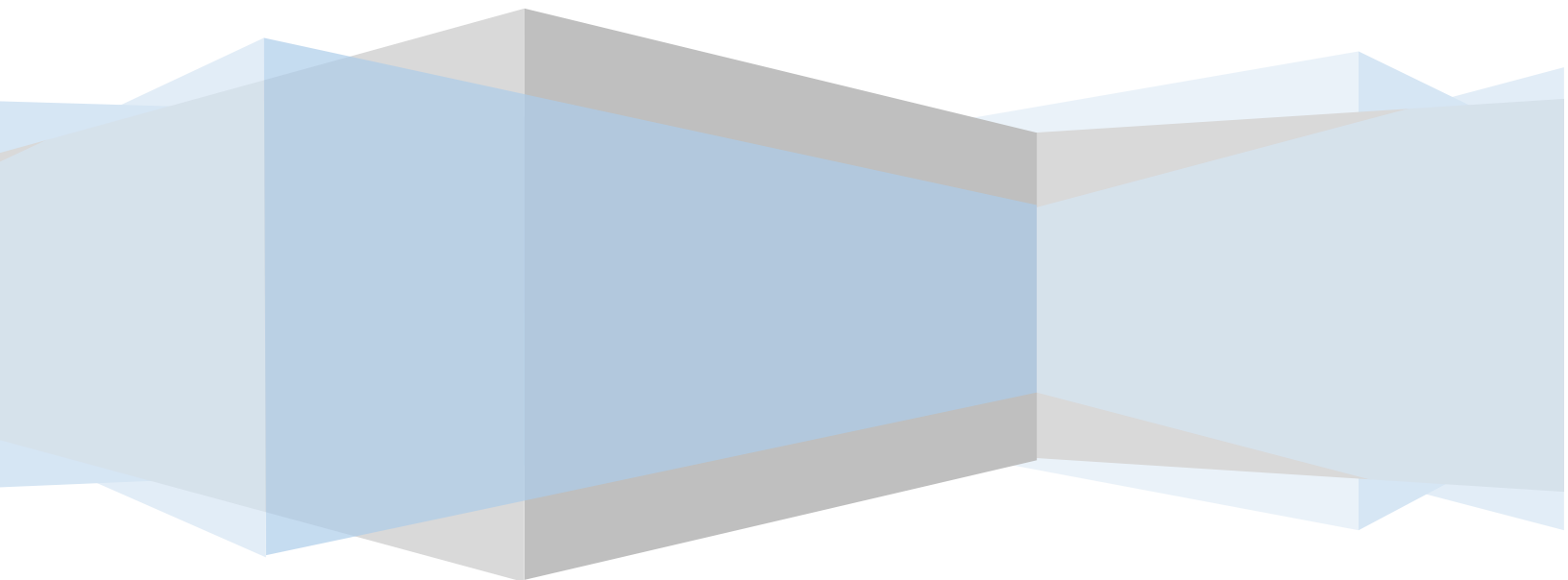


POST OPERATIONS ANALYSIS REPORT

April, 2023

CENTRAL COMMAND CENTER, C-ATFM, DELHI







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A. Executive Summary

Domestic air traffic has recorded a growth of 2.2 % whereas the international air traffic declined by 4.0 % in the month of April'23 as compared to March'23.

On average, the Indian Airports in the ATFCM area saw 4821 IFR flights per day in the month of April 2023. The peak day was on 28th April 2023 (5017 IFR flights). Thursday's were the busiest days throughout this month with an average of 4241 domestic IFR flights per day.

Total Twenty one (21) ATFM measures were applied this month during periods of congestion at Delhi,Chennai, Bengaluru and Mumbai Airports.

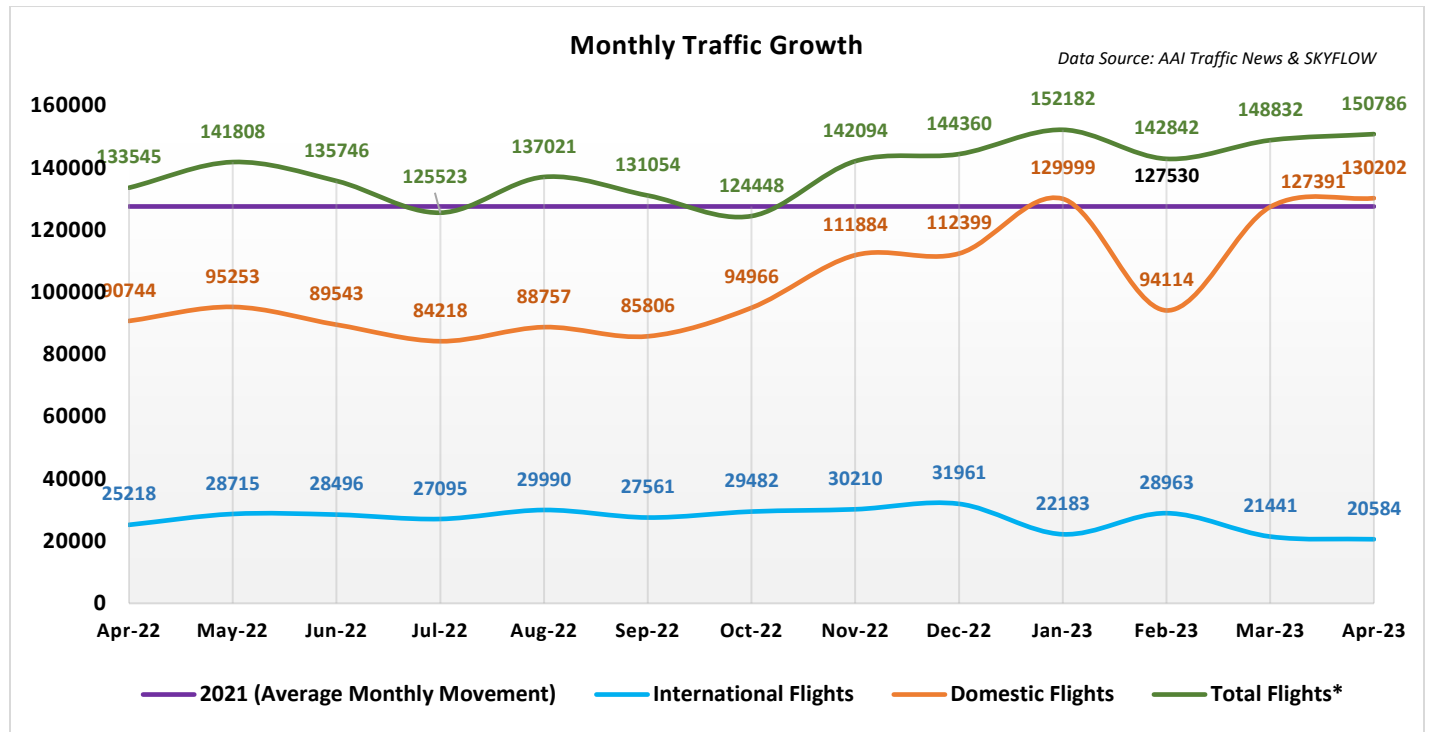


Figure 1: Monthly Traffic Growth

*Total Flights includes flights Overflying Indian Airspace along with Domestic and International traffic landing and taking off from Indian Airports.

The graph above depicts the Domestic and international Air traffic in Indian ATFCM Area during the last 13 months (Apr'2022 to Apr'2023).



B. Traffic Analysis

I. Air Traffic Movement at Major Airports in India

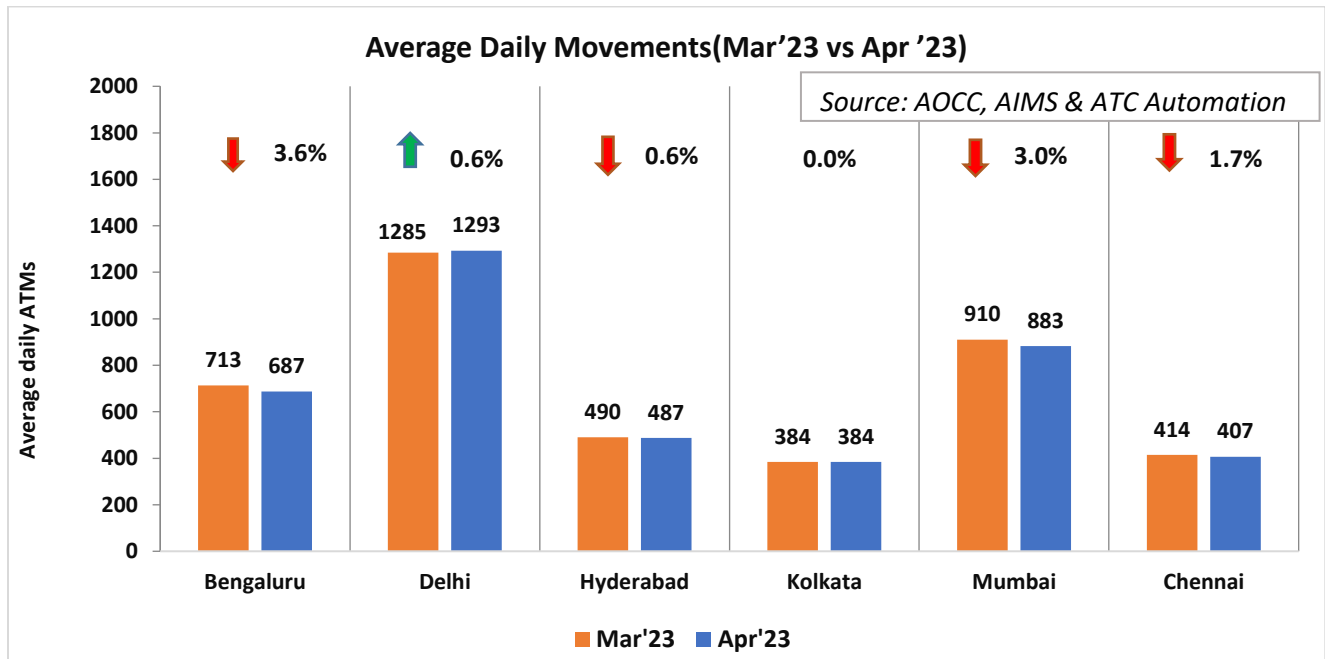


Figure 2: Average Daily Movements (Mar'23 vs Apr'23)

The above chart depicts the percentage change in average daily ATMs at six major Airports in Apr'23 compared to the previous month (Mar'23).

Airports\Year	Avg. Daily ATMs (YoY) for six major airports				
	Apr'19	Apr'20	Apr'21	Apr'22	Apr'23
Bengaluru	628	16	424	557	687
Delhi	1201	48	931	1210	1293
Hyderabad	492	8	305	440	487
Kolkata	443	14	290	376	384
Mumbai	707	33	480	753	883
Chennai	450	15	286	353	407



Air Traffic Movement for each day in Apr'23 is plotted for Delhi, Mumbai, Bengaluru and Hyderabad Airport along with the percentage change w.r.t. Avg. Daily Movement for the same month.

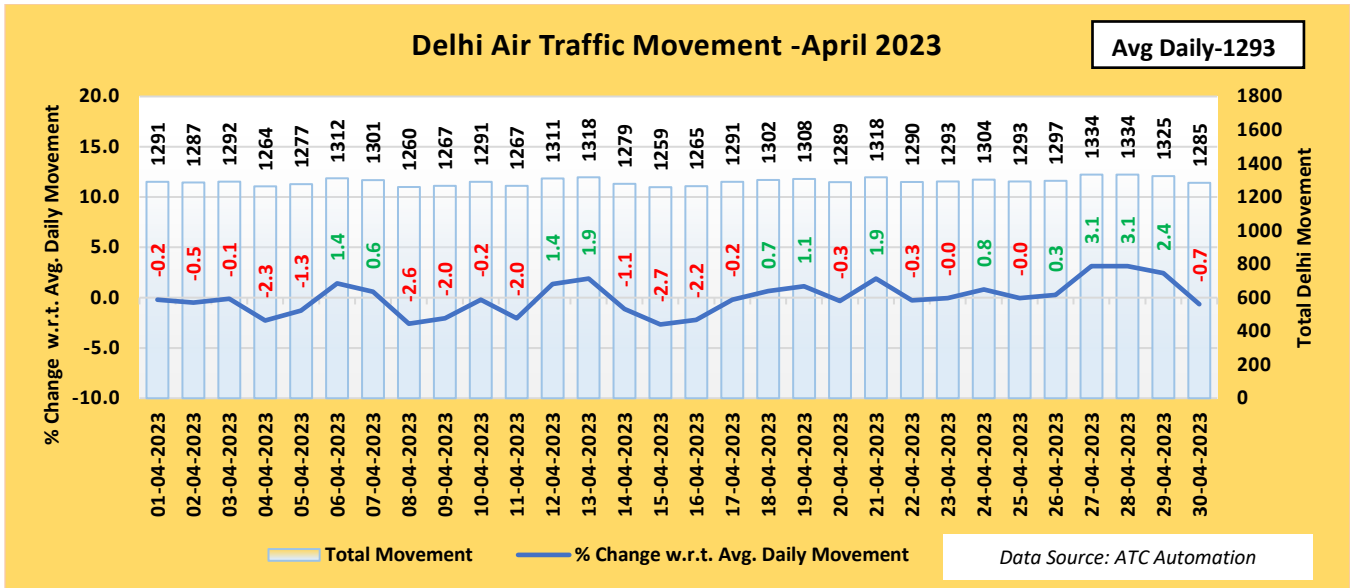


Figure 3: Air Traffic Movement for Delhi –April 2023

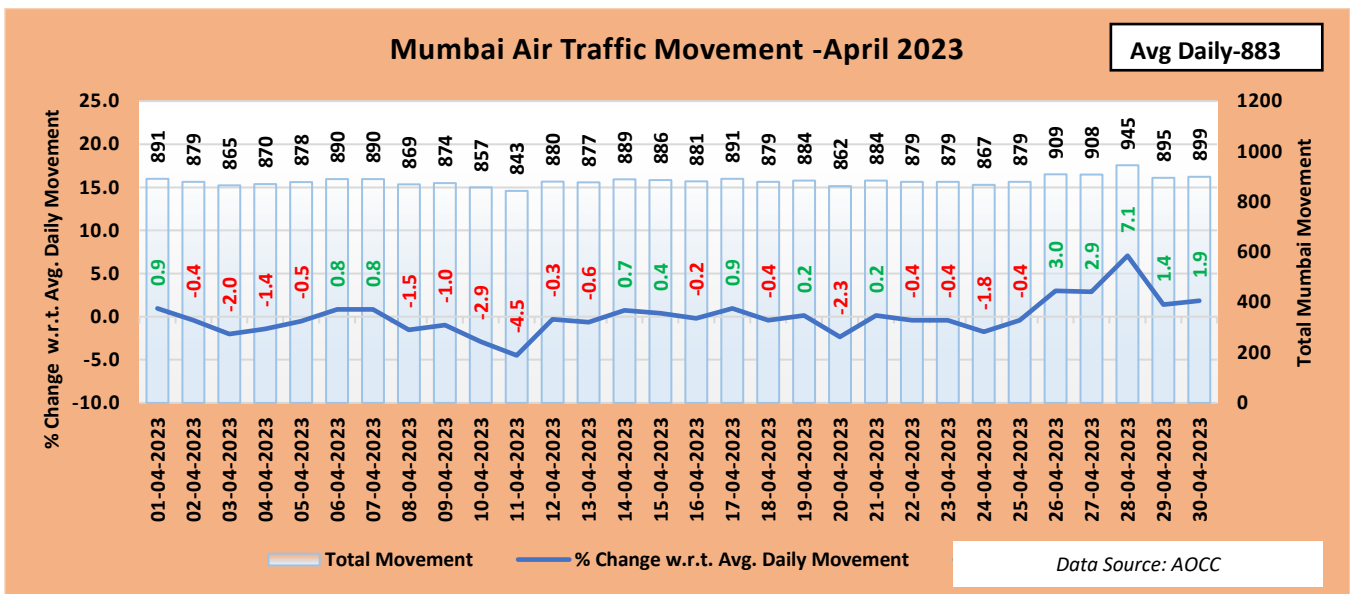


Figure 4: Air Traffic Movement for Mumbai - April 2023

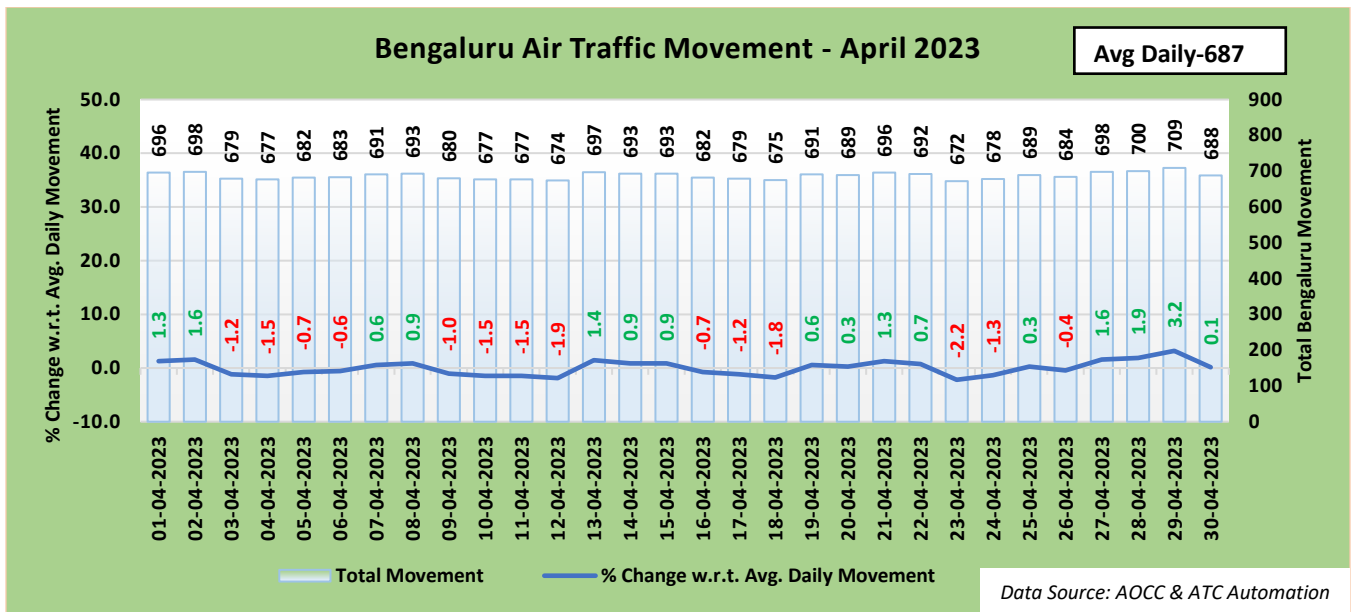


Figure 5: Air Traffic Movement for Bengaluru – April 2023

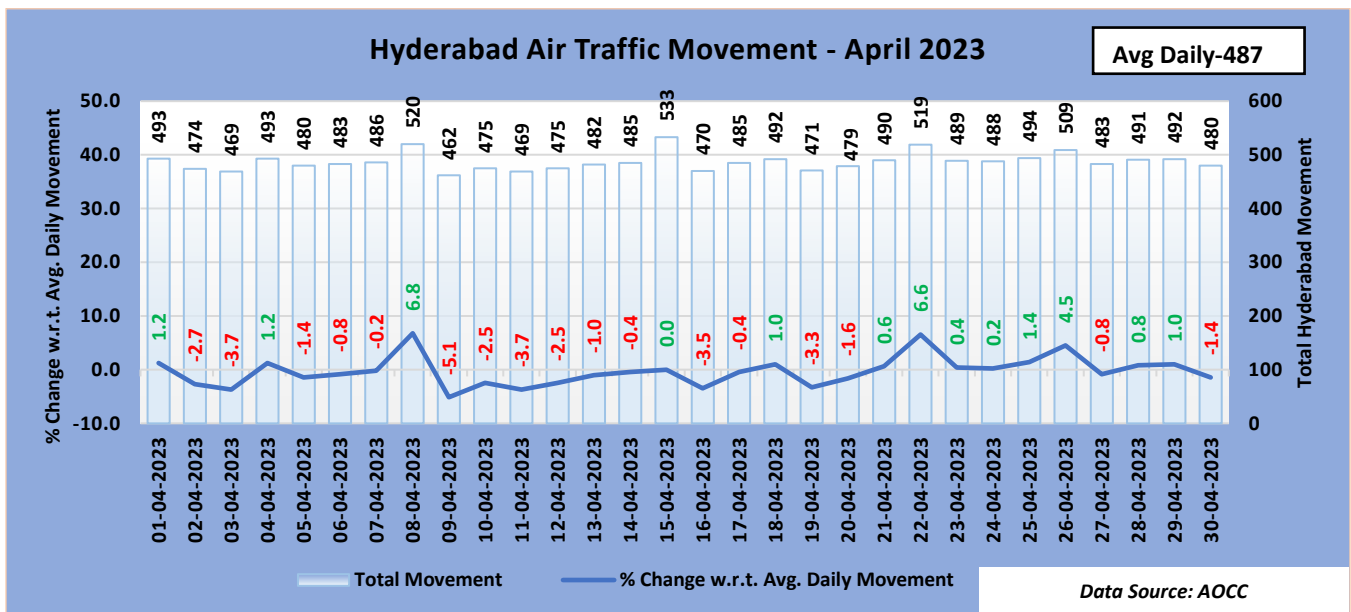


Figure 6: Air Traffic Movement for Hyderabad - April 2023

It is evident from the above charts that on month end(30th April 2023) the ATMs at Delhi and Hyderabad saw a decline of 0.7% and 1.4% respectively whereas Mumbai and Bengaluru saw an increase of 1.9% and 0.1% respectively as compared to the average daily movement for the month of April'23.



II. Comparison of total ATMs (YoY) and Monthwise

The total Air traffic movement(ATMS) including Passenger and other flights such as Cargo flights, International scheduled, International non-scheduled, Domestic scheduled, Domestic non-scheduled, Air taxi & commercial business flights at six major Indian Airports namely Delhi, Mumbai, Bengaluru, Hyderabad, Kolkata and Chennai is plotted for the month of April for two consecutive years 2022 and 2023 respectively. Air Traffic movement is also plotted Airline wise for the last six months for the major Scheduled Operators.

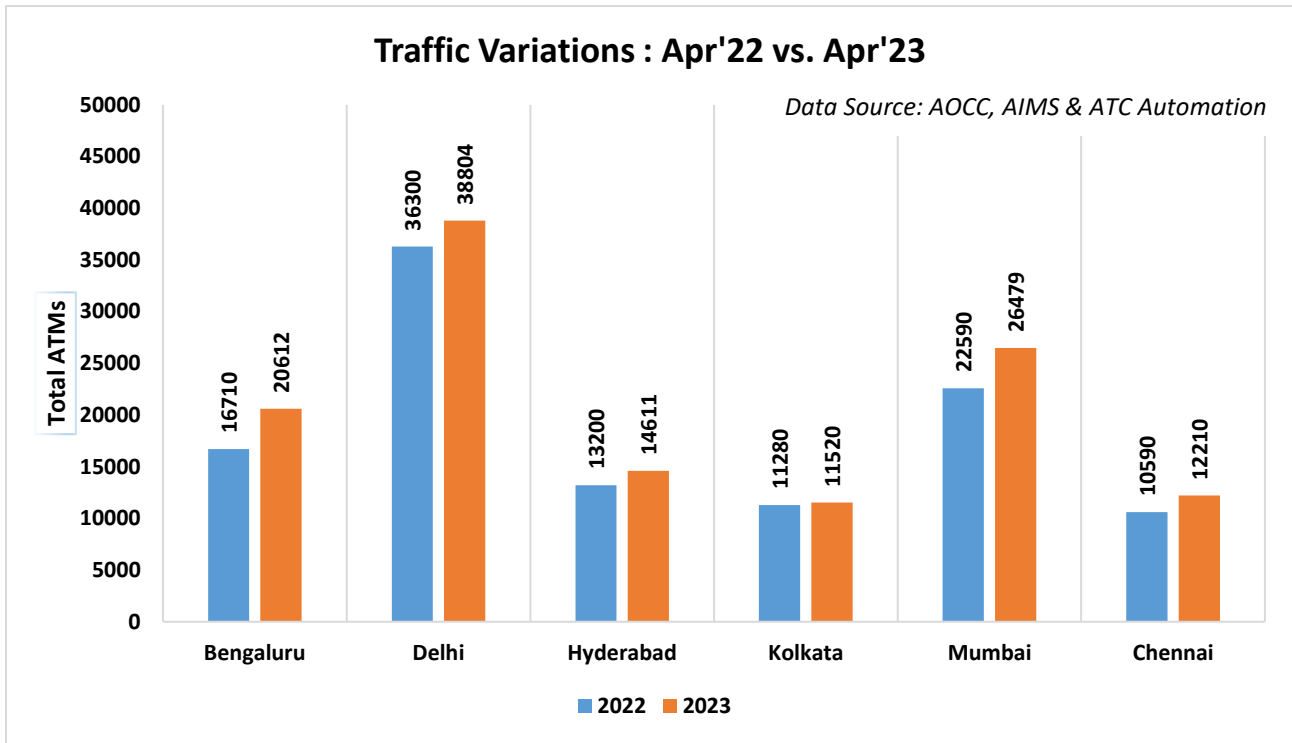


Figure 7: Traffic Variation (YoY)



III. Flight Operations – Airlinewise

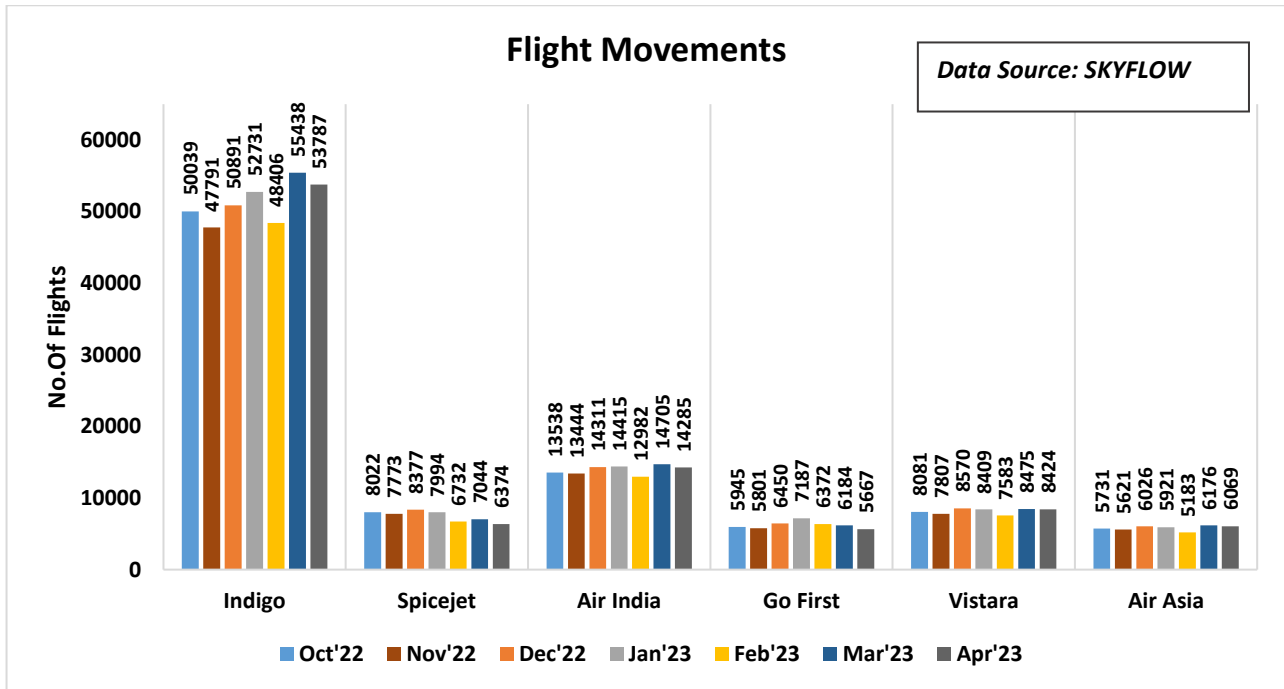


Figure 8: Flight Movements –Airlinewise

Inference:

1. Indigo, Air India, Vistara, and Air Asia Airlines have recorded a higher monthly average Flight movement in Apr'23 as compared to Mar'23 whereas Spicejet and Go first see a marginal decline.



C. ATFM Post Operations – CDM Analysis

I. Introduction

Analysis Period 1st – 30th April 23

Back Ground During the above mentioned period, **Nine (09)** ATFM measures were applied for **Delhi Airport**, **Seven (07)** ATFM measures were applied for **Bengaluru Airport**, **Three (03)** ATFM measures were applied for **Chennai Airport** and **Two (02)** ATFM measures were applied for **Mumbai Airport** due to the following reasons as illustrated in the bar chart below:-

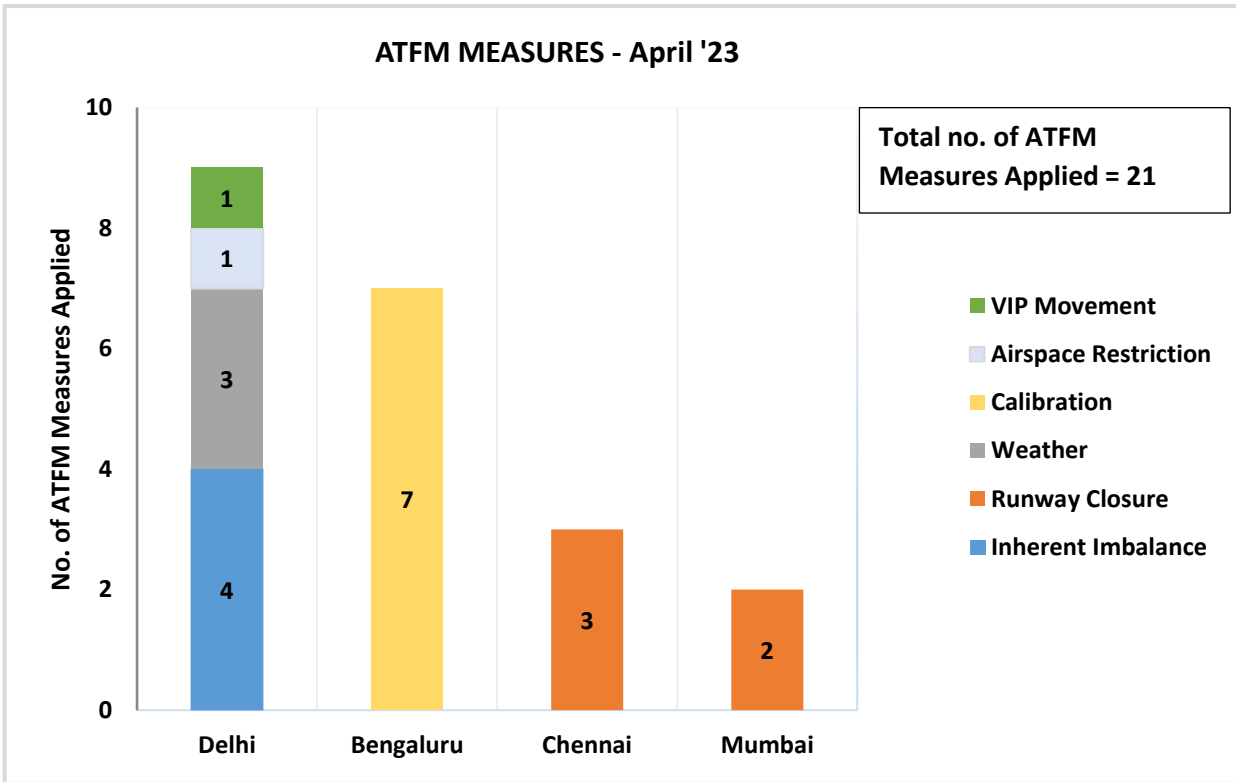


Figure 9: ATFM Measures –April'23



II. ATFM Measures Overview

Constrained Airport	Delhi	Mumbai	Bengaluru	Chennai
Number of ATFM measures applied	9	2	7	3
Average ATFM Ground delay(in min) due to measures*	17.8	9.8	17.8	18.4
Maximum ATFM Ground delay(in min) due to measures	67	28	56	29
% Compliance	72.5	83.3	75.7	95.3

Note: * *Average ATFM Delay* = $\frac{\text{Total ATFM Delay}}{\text{Total Domestic Arrivals}}$

Total Arrivals	1065
Total International Arrivals(exempted)	168
Total affected flights in scenario (Domestic Arrivals)	897
Total Domestic Arrivals with zero ATFM delay	106
Total Domestic Arrivals with ATFM delay	791

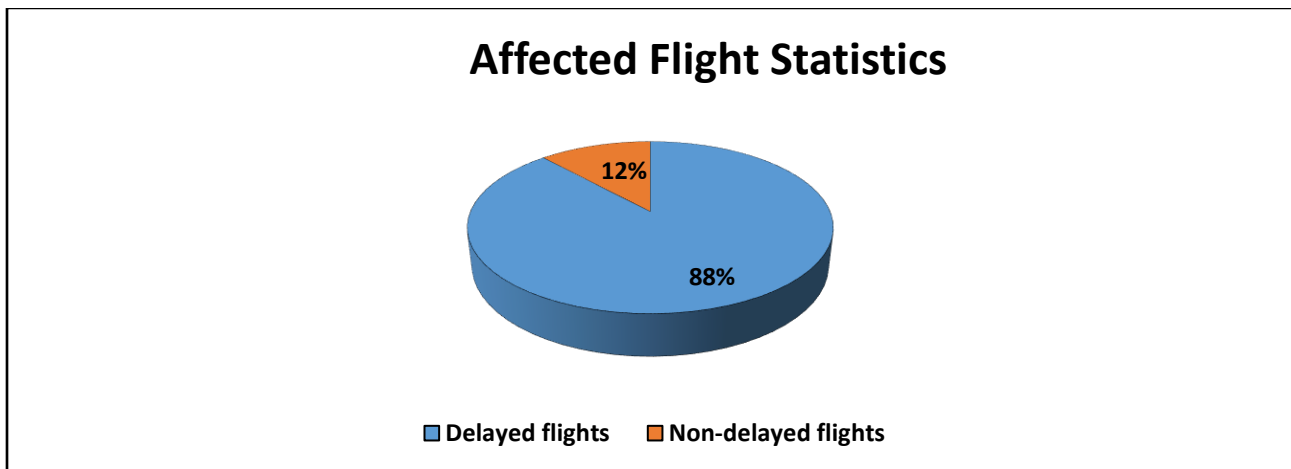


Figure 10: Affected Flight Statistics –Apr'23



III. Overall Compliance

Total arrivals	1065
Domestic arrivals	897
Flights with complete data (ATOT)	874
Flights with incomplete data	8
Flights Not Operated	15
Compliant*	657
Non-Compliant	217

*Total No. of Revised CTOTs issued = 145 (Compliance calculation for flights which were issued revised CTOT is w.r.t. new CTOT issued)

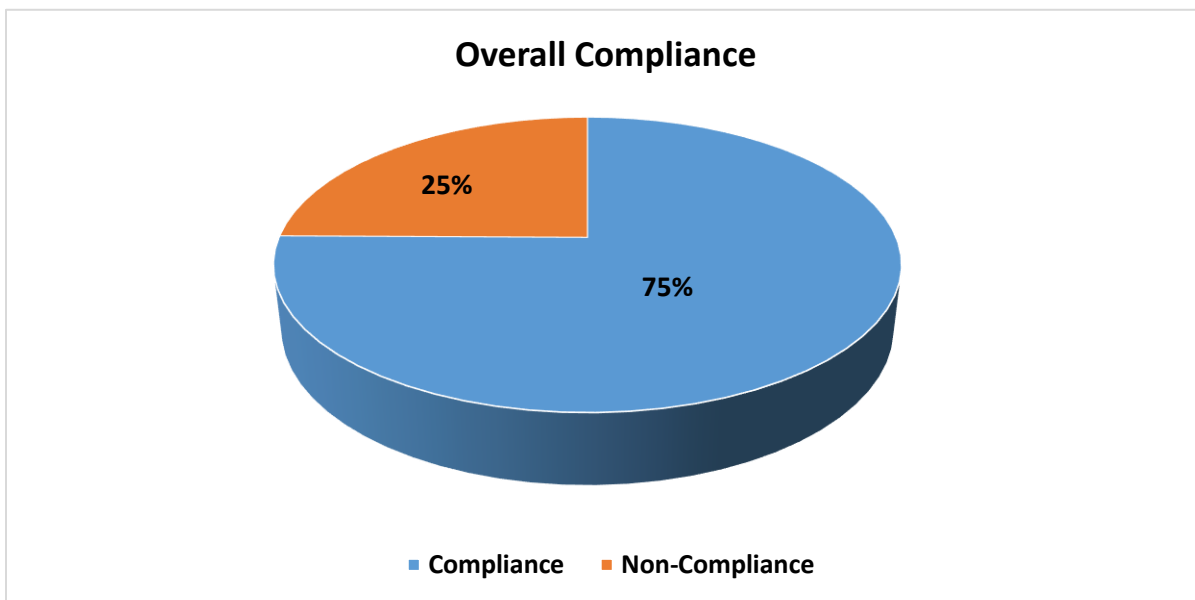


Figure 11: Overall Compliance – Apr'23

NOTE: Flights with required data (i.e. ATOT) are only considered for compliance measurement

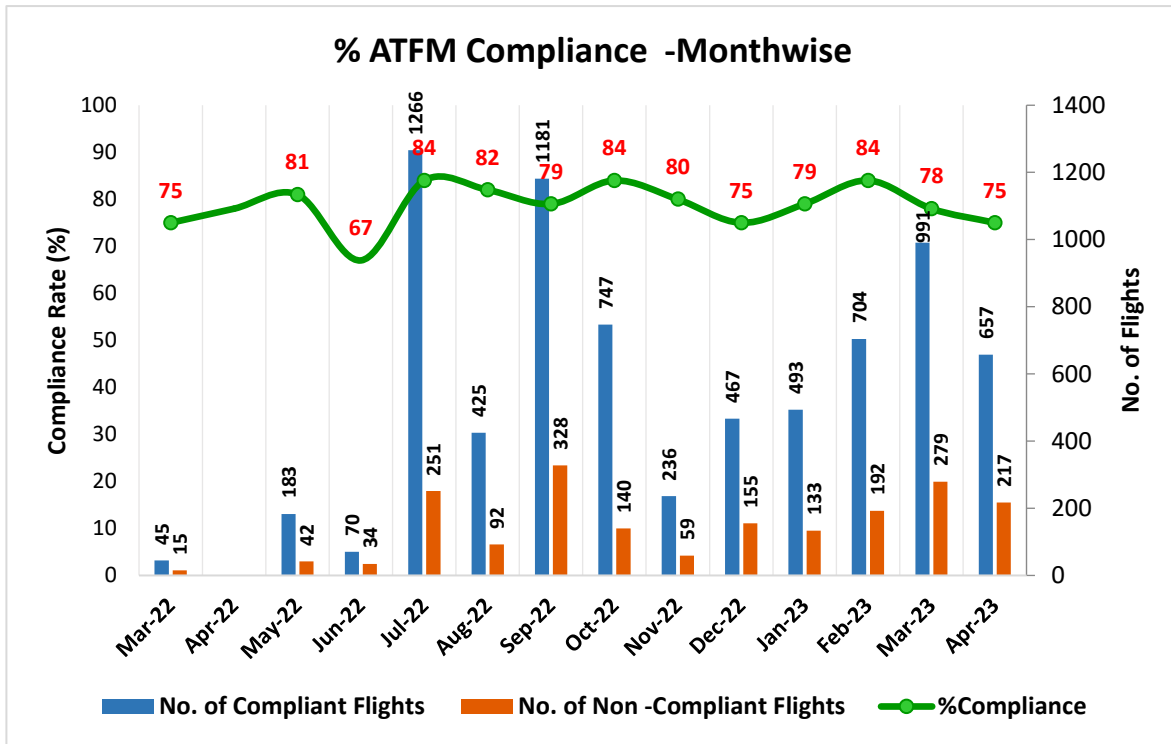


Figure 12: Compliance(Monthwise)

Inference

1. Out of the total arrivals captured(1065 flights) during the CDM scenario for the constrained Airports, 84% of flights i.e. domestic arrivals(897 flights) were candidates for ground delay(participating).
2. Out of these Domestic Arrivals, 88% (791 flights)are assigned ATFM ground delay.
3. Out of the total arrivals captured(1065 flights) to the constrained Airport during the ATFM scenario, only 74% of flights(791 flights) were assigned ATFM Ground Delay.



IV. CTOT Compliance rate – Airportwise

MUMBAI FIR (76%)*	Compliant	Non Compliant	% Compliant
Ahmedabad	17	3	85%
Aurangabad	1	0	100%
Mumbai	57	18	76%
Vadodara	4	1	80%
Bhopal	8	0	100%
Indore	9	2	82%
Jabalpur	2	0	100%
Jamnagar	2	1	67%
Kandla	2	1	67%
Maharashtra	1	1	50%
Nagpur	7	1	88%
Pune	21	10	68%
Rajkot	9	2	82%
Shirdi	6	5	55%
Surat	5	2	71%
Udaipur	0	1	0%
KOLKATA FIR (76%)*	Compliant	Non Compliant	% Compliant
Prayagraj	5	2	71%
Siliguri	17	5	77%
Varanasi	10	3	77%
Bhubaneswar	12	1	92%
Kolkata	33	10	77%
Chakeri	1	2	33%
Durgapur	9	0	100%
Darbhanga	3	1	75%
Gorakhpur	3	3	50%
Guwahati	22	8	73%
Gaya	0	1	0%
Jharsuguda	3	2	60%
Kushinagar	3	0	100%
Khajuraho	1	0	100%
Dibrugarh	4	2	67%
Patna	16	4	80%
Ranchi	14	6	70%



DELHI FIR (66%)*	Compliant	Non Compliant	% Compliant
Raipur	9	1	90%
Agra	0	2	0%
Amritsar	4	2	67%
Bikaner	2	1	67%
Bareilly	1	0	100%
Chandigarh	9	7	56%
Dehradun	6	0	100%
Delhi	24	10	71%
Kangra	2	0	100%
Gwalior	3	0	100%
Hissar	0	1	0%
Halwara Air Force Station	0	1	0%
Jodhpur	6	2	75%
Jaipur	7	7	50%
Jammu	3	1	75%
Leh	5	2	71%
Lucknow	23	3	88%
Srinagar	14	18	44%
Sirsa	1	0	100%
CHENNAI FIR (80%)*	Compliant	Non Compliant	% Compliant
Bangalore	38	9	81%
Belgaum	2	1	67%
Vijayawada	5	2	71%
Coimbatore	15	1	94%
Kochi	30	5	86%
Calicut	1	0	100%
Kadapa	0	1	0%
MOPA Goa	13	6	68%
Gulbarga	3	0	100%
Goa	21	9	70%
Hubli	4	0	100%
Hyderabad	36	8	82%
Begumpet Hyderabad	2	1	67%
Vijaynagar	1	1	50%



Kurnool	4	0	100%
Madurai	6	3	67%
Mangalore	2	0	100%
Chennai	24	3	89%
Port Blair	2	4	33%
Pondicherry	0	1	0%
Sindhudurg	2	0	100%
Tuticorin	5	0	100%
Tirupati	2	1	67%
Thiruvananthapuram	12	1	92%
Visakhapatnam	2	2	50%

**FIR wise compliance rate*

Note: The above list contains only those airports which had flights to the Constrained Airport and are affected by ATFM measures.

Airports with % compliance less than the average compliance(75%) for the month are highlighted in red.



V. CTOT Compliance rate – Airline wise

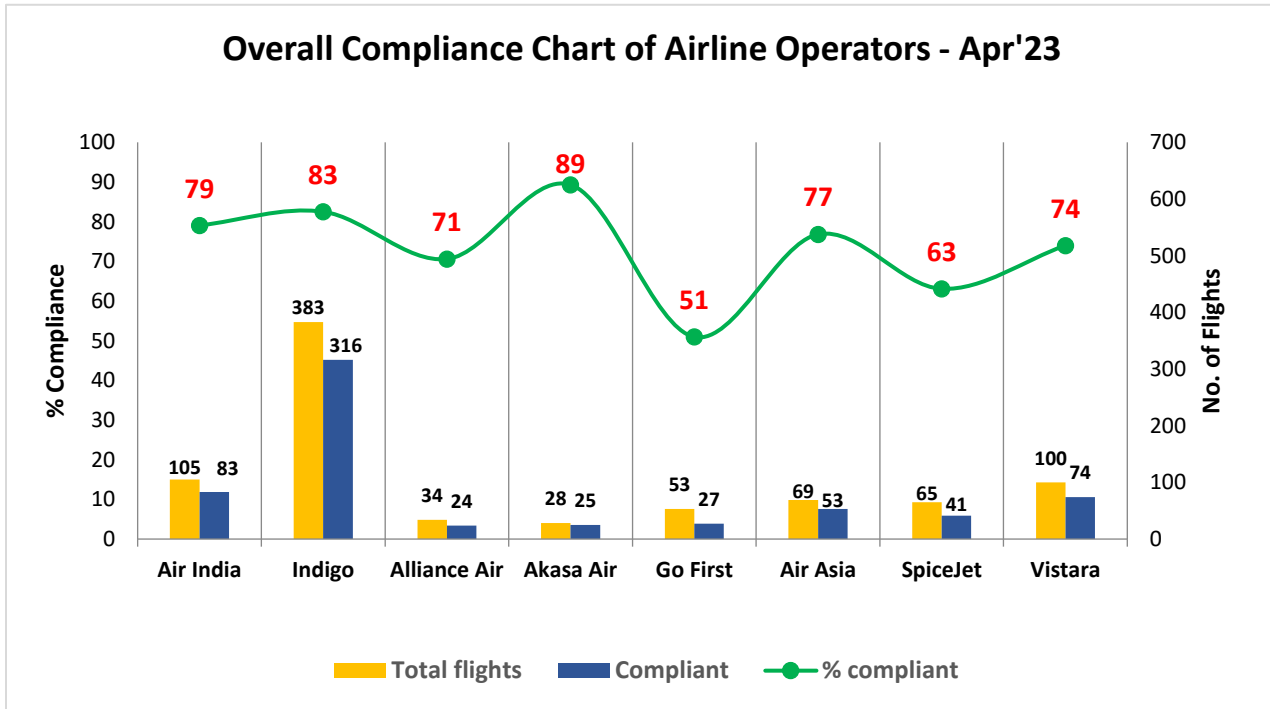


Figure 13: Airline wise Compliance –Apr’23

Inference

1. Out of the total domestic arrivals with complete data in the CDM scenario, 75% arrivals are compliant.
2. Chennai region has the highest compliance rate of 80% whereas Delhi region has the lowest compliance rate of 66%.
3. Air India, Indigo, Akasa Air, and Air Asia Airlines have a CTOT compliance higher than the average recorded compliance for the month of Apr’23.

VI. Reason For Non Compliance

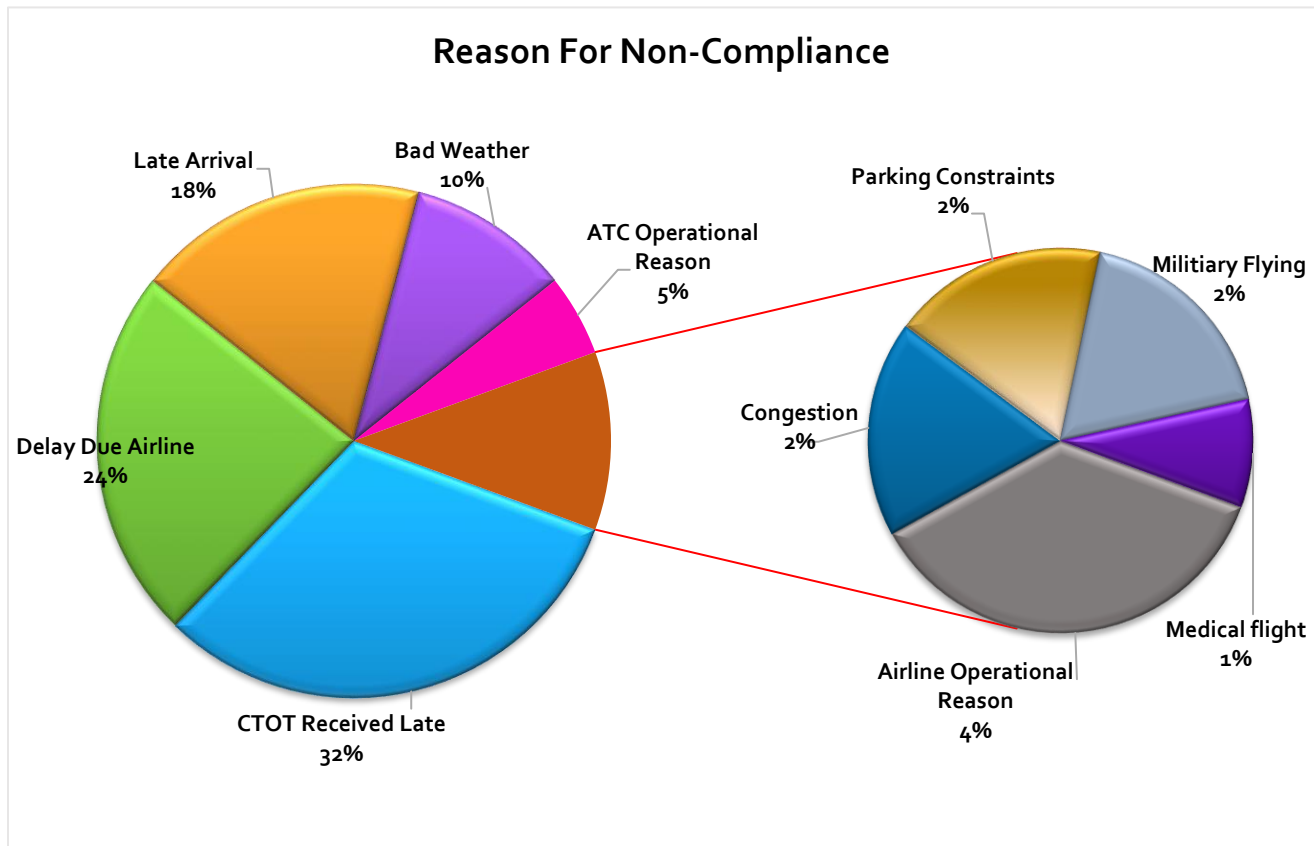


Figure 14: Reason for Non-Compliance as provided by FMPs

Inference:

1. 32 % of the CTOT Non- compliance was reported by concerned FMPs due to late receiving of CTOTs and by the time the aircraft had initiated pushed back or startup. Few of the ATFM measures were initiated at short notice resulting in delay in dissemination of CTOTs.
2. 24% of the CTOT Non- compliance was reported by concerned FMP to be because of delay due airlines.
3. 18% of the CTOT Non- compliance was reported because of flights being delayed from the previous arrival leg. The revised EOBT was not available to CCC/ATC station resulting in wastage of unused slots.

VII. Air Delay during the CDM Scenario period

Average Air Delay to domestic arrivals* within the CDM Scenario period for Delhi, Mumbai, Bengaluru and Chennai was 7.7, 5.4, 4.2 and 13.5 minutes respectively.

*Note: Only calculated for domestic arrivals with both ATOT and ALDT information

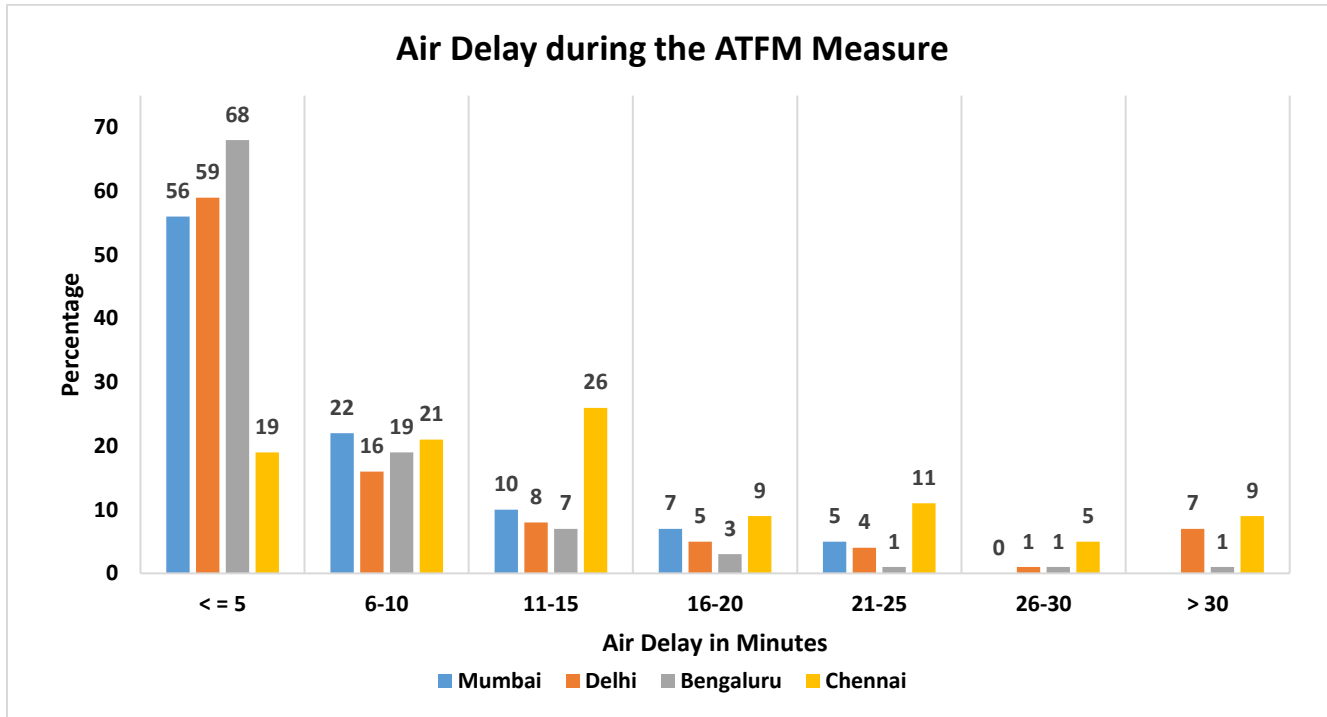


Figure 15: Air Delay distribution during the CDM period

Inference

1. 78% of domestic arriving flights to Mumbai had an Air delay of equal to or less than 10 minutes during the CDM period.
2. 75% of domestic arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period.
3. 87% of domestic arriving flights to Bengaluru had an Air delay of equal to or less than 10 minutes during the CDM period.
4. 40% of domestic arriving flights to Chennai had an Air delay of equal to or less than 10 minutes during the CDM period.



Tangible Benefits due to ATFM Measures

A modest attempt is made to find out the tangible benefit of ATFM measures applied.

Assumptions:

- When ATFM measures are not in force, all flights take off at their ETOT where Estimated take off time(ETOT)= Estimated off block time(EOBT) + default taxi time
- All flights have an Estimated elapsed time(EET) as calculated by SKYFLOW using the Flight Plan information and Basic Aircraft data.

Methodology:

Air delay (with ATFM measures in force) is calculated during the period when ATFM measures are in force by summing the air delay for all the flights landing at constrained Airport.

i.e. **Total Air Delay = \sum (Actual Flying time – SKYFLOW calculated EET)**

Air delay (with no ATFM measures) is calculated as the sum of Air delay for all the flights during the above said period with no ATFM measures in place and the air delay for each flight is the difference in its ideal landing time and its ideal estimated landing time.

Total Air Delay (with no ATFM measures) = \sum (Ideal LDT - Ideal ELDT)

*Ideal LDT is taken by assuming every flight is landing at a specified interval based on the Arrival acceptance rate(AAR) defined,

*Ideal ELDT = ETOT + SKYFLOW calculated Flying time

Fuel Saving Calculation :

Great Circle Distance(GCD)* was calculated for all the arrivals during the ATFM Measure from the point of origin to destination. Assuming Airbus 320 as reference aircraft for domestic flights (flight distance equal to or less than 3000 nm) and B777 for international flights (flight distance more than 3000nm):

Fuel consumption (Kgs / nm) for each affected flight in the scenario was then calculated using the Reference document: ICAO Carbon emissions calculator methodology, version10, Appendix C: ICAO Fuel Consumption Table.

The Fuel consumed per minute(Kg/min) was calculated for each affected flight.



Total Air Delay(with ATFM Measures)= 2762 mins

Total Air Delay (with no ATFM measures) = 14111 mins

Reduction in Air delay due to ATFM measures= (14111-2762) = **11349 mins**

Fuel Saving Calculation:

Total Fuel saved during the ATFM Measure: **6,02,795.59 Kg**

Total reduction in CO₂ emission : 3.16(KgCO₂/kg fuel)* 6,02,795.59 Kg = 1,904,834.06Kg

**GCD (Great Circle Distance): The distance between origin and destination airports is derived from latitude and longitude coordinates originally obtained from ICAO Location Indicators database.*

3.16 = constant representing the number of tonnes of CO₂ produced by burning a tonne of aviation fuel.



D. Glossary

ATFM Parameters	Definition
<i>Affected Flight statistics</i>	An insight of participating traffic in the scenario i.e. ratio of the domestic arrivals to the constrained airport affected by ATFM measures (assigned delay by the Ground Delay Program) to the domestic arrivals not affected by ATFM measures (not assigned any delay) within the CDM scenario.
ATFM Ground delay	ATFM ground delay defined as CTOT-ETOT (Calculated take off time – Estimated take off time)
<i>Average ATFM delay</i>	$\frac{\text{Total monthly ATFM delay (in minutes)}}{\text{Total Domestic Arrivals}}$
<i>Maximum ATFM delay</i>	Maximum ATFM delay (in minutes) assigned in the month
<i>Overall compliance rate</i>	Defined as monthly ATFM departure slot adherence rate of regulated flights. Flights having ATOT within the ATFM Slot Tolerance Window (STW) of minus 5 to plus 10 minutes of CTOTs, are considered as compliant flights
<i>CTOT Compliance rate of Airline operators</i>	An overview of CTOT compliance rate of various Airline operators
<i>CTOT Compliance rate of Airports within different Regions</i>	An overview of CTOT compliance rate of Airports within 4 FIRs
Air delay statistics	<p>Air delay defined as difference between AET & EET, where AET (actual elapsed time) can be obtained from (ALDT-ATOT) and estimated elapsed time (EET) can be obtained from FPL/RPL or (CLDT-CTOT). Therefore, Air delay = AET-EET</p> <p>Average Air Delay is calculated as:</p> $\text{Average Air Delay} = \frac{\text{Total Air Delay to domestic arrivals (with values greater than zero)}}{\text{Total Domestic Arrivals}}$ <p>CLDT: Calculated Landing Time CTOT: Calculated Take off Time ALDT: Actual Landing Time ATOT: Actual Take off Time</p>