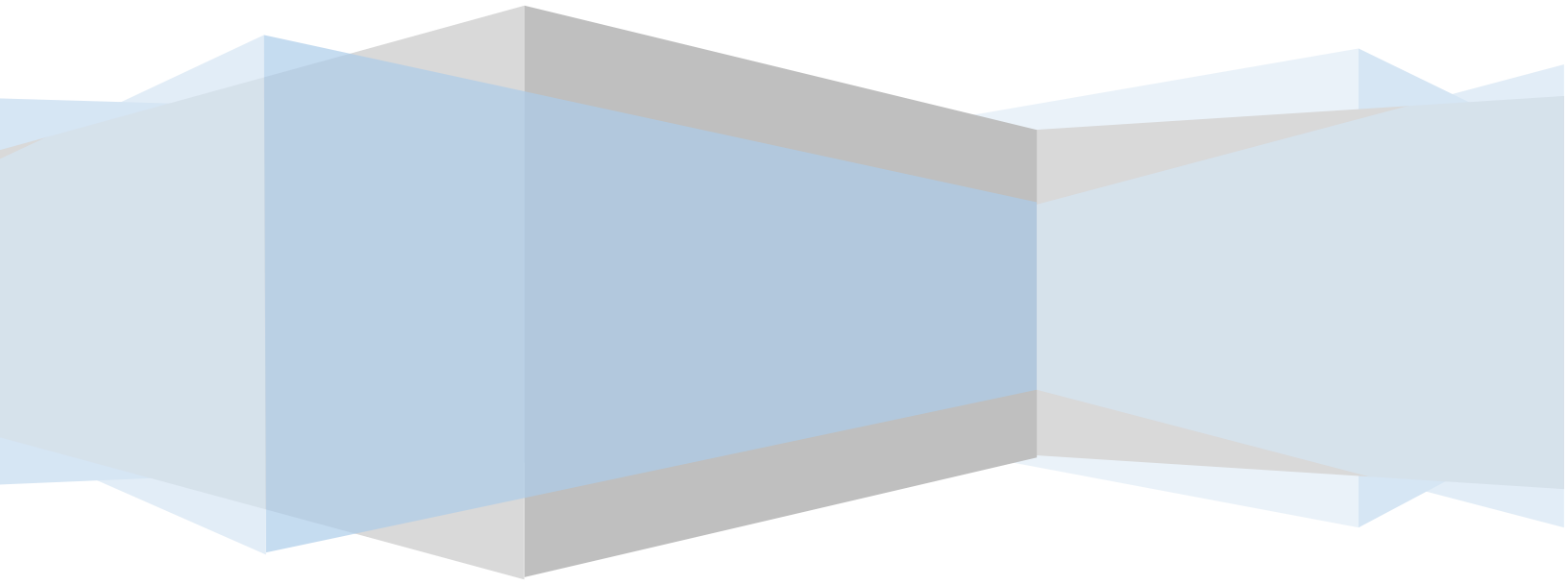
POST OPERATIONS ANALYSIS REPORT

May, 2023

CENTRAL COMMAND CENTER, C-ATFM, DELHI



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A. Executive Summary

Domestic air traffic has recorded a decline of 2.7 % whereas the international air traffic increased by 17% in the month of May'23 as compared to April'23.

On average, the Indian Airports in the ATFCM area saw 4730 IFR flights per day in the month of May 2023. The peak day was on 25th May 2023 (4903 IFR flights). Thursday's were the busiest days throughout this month with an average of 4124 domestic IFR flights per day.

Total Ten(10) ATFM measures were applied this month during periods of congestion at Delhi,Chennai and Mumbai Airport.

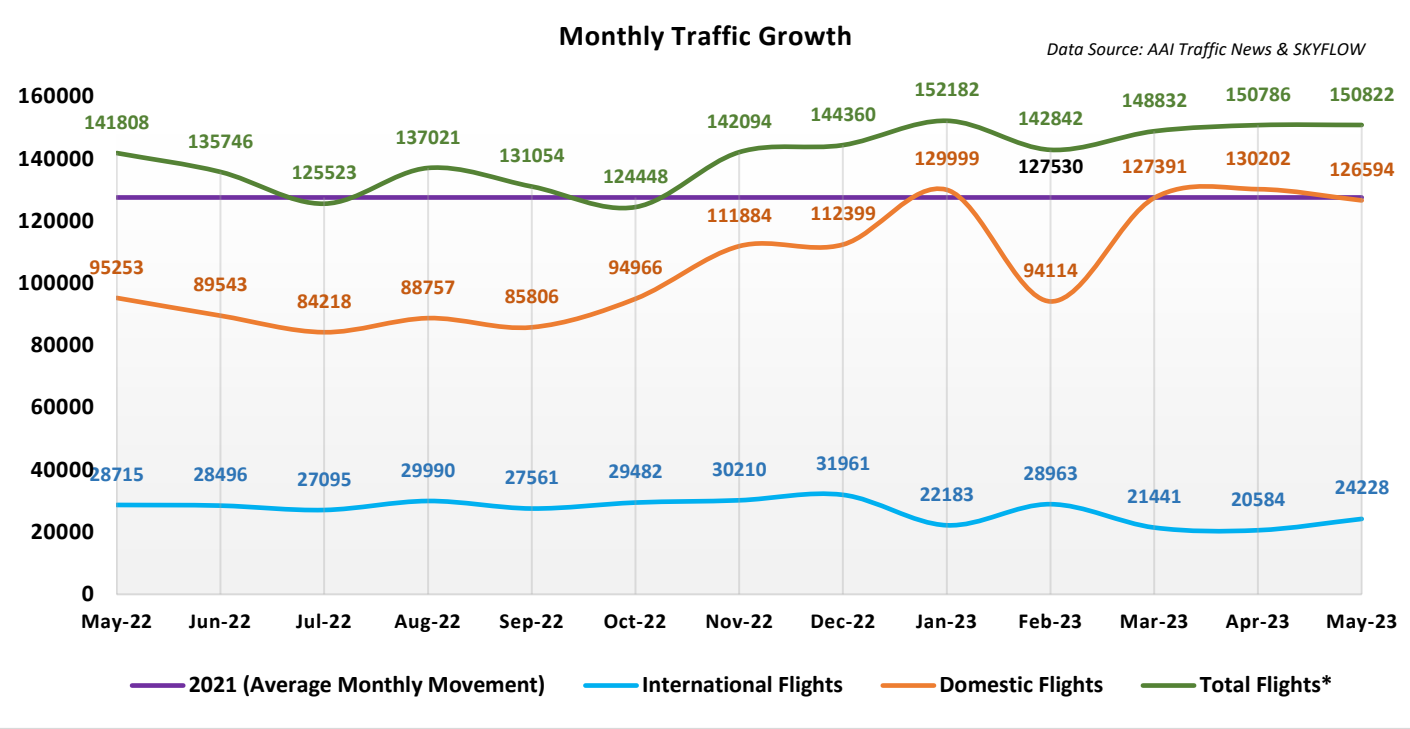

Figure 1: Monthly Traffic Growth

**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 (May'2022 to May'2023).

B. Traffic Analysis

I. Air Traffic Movement at Major Airports in India

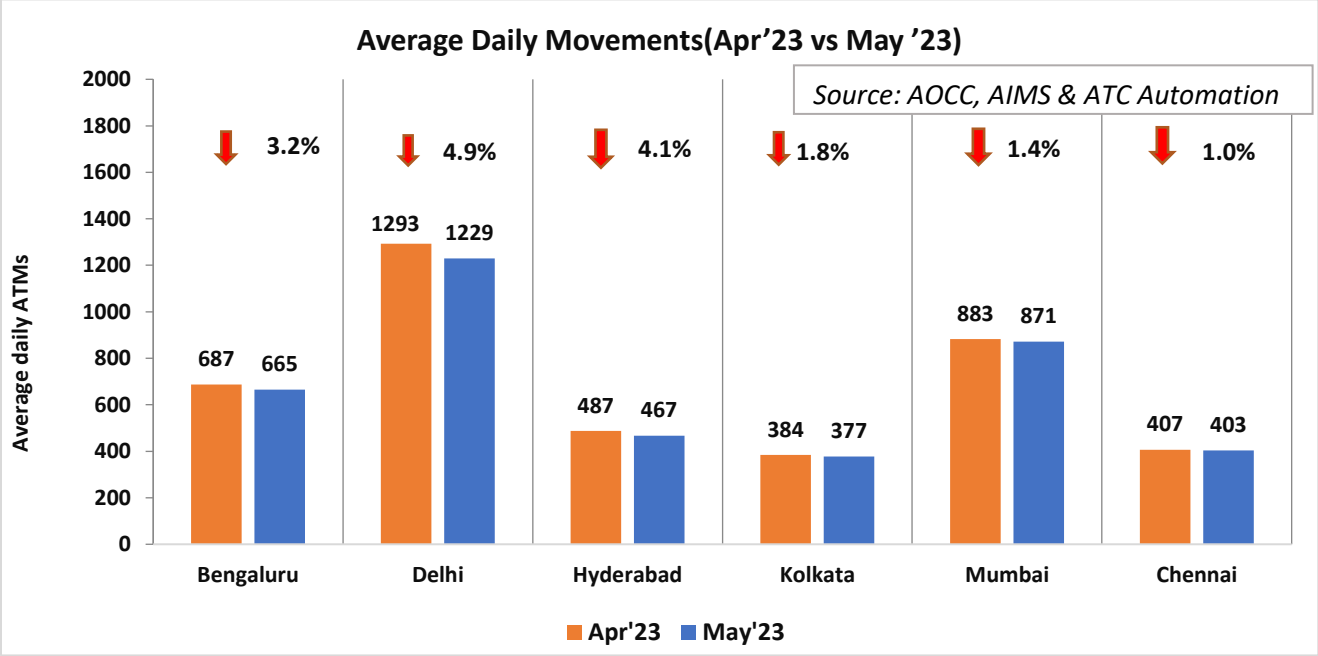

Figure 2: Average Daily Movements(Apr'23 vs May'23)

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

Airports\Year	Avg. Daily ATMs (YoY) for six major airports				
	May'19	May'20	May'21	May'22	May'23
Bengaluru	634	50	204	583	665
Delhi	1230	132	528	1220	1229
Hyderabad	503	27	157	441	467
Kolkata	425	26	143	390	377
Mumbai	790	60	252	798	871
Chennai	457	37	141	361	403

Air Traffic Movement for each day in May'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.

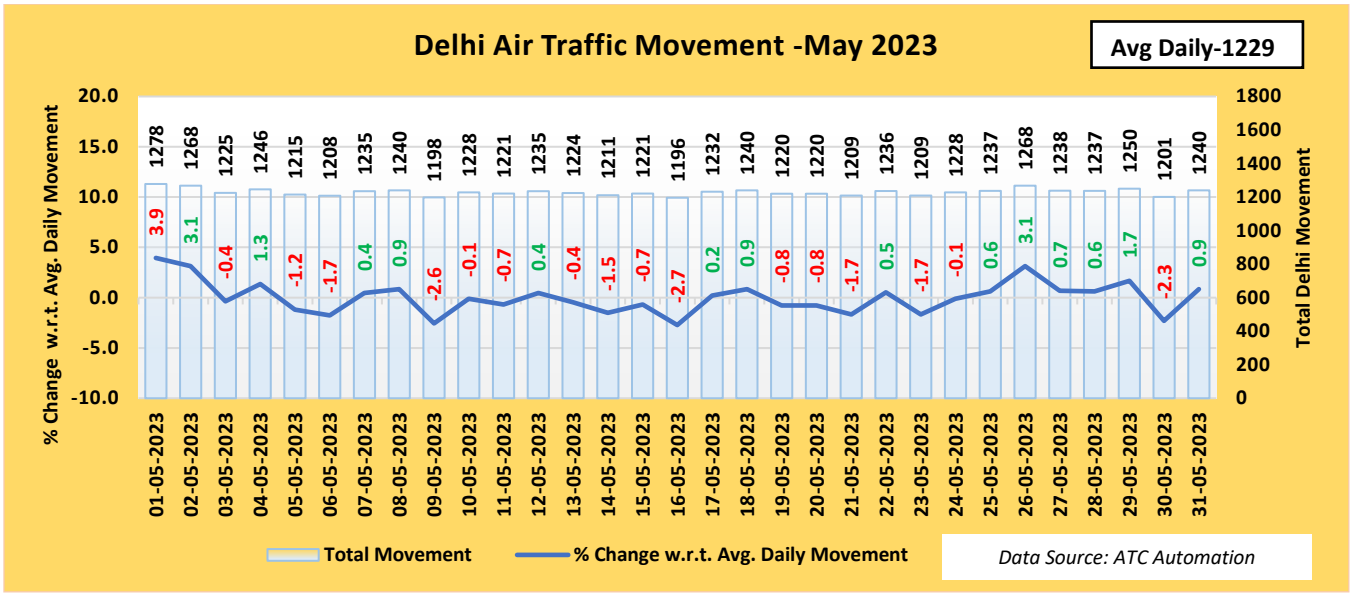

Figure 3: Air Traffic Movement for Delhi –May 2023

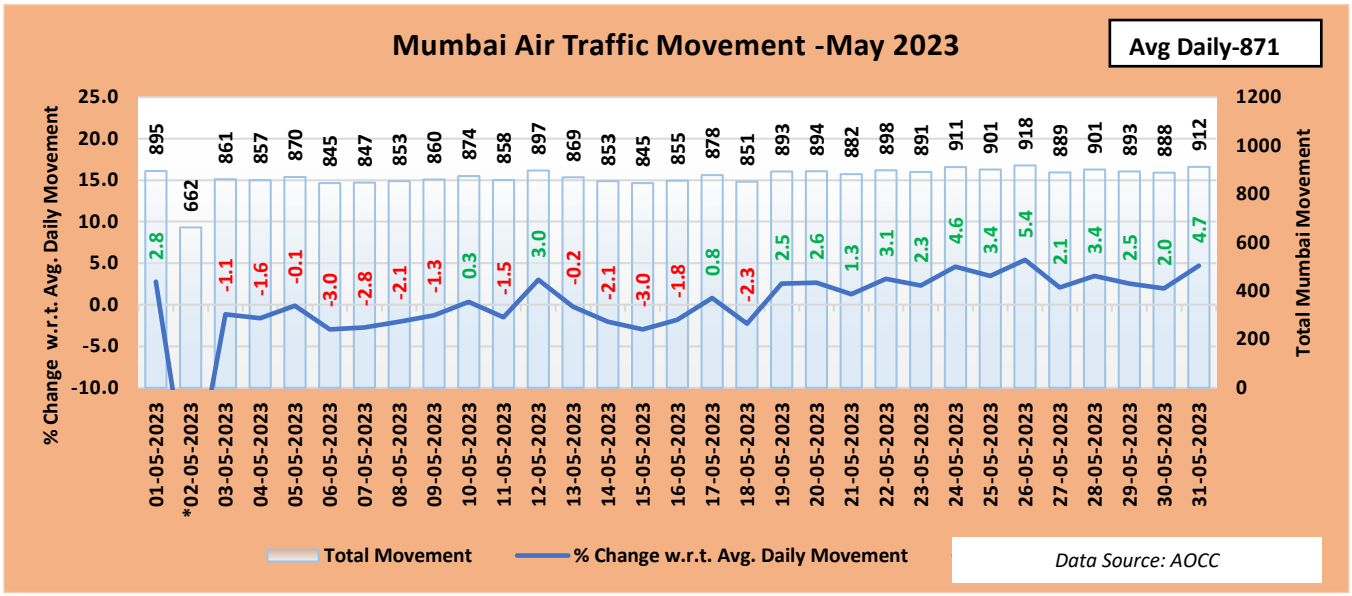

Figure 4: Air Traffic Movement for Mumbai - May 2023

* Runway Intersection closure in Mumbai on 02-05-2023 from 0530 UTC to 1130 UTC due pre-monsoon preventive maintenaince.

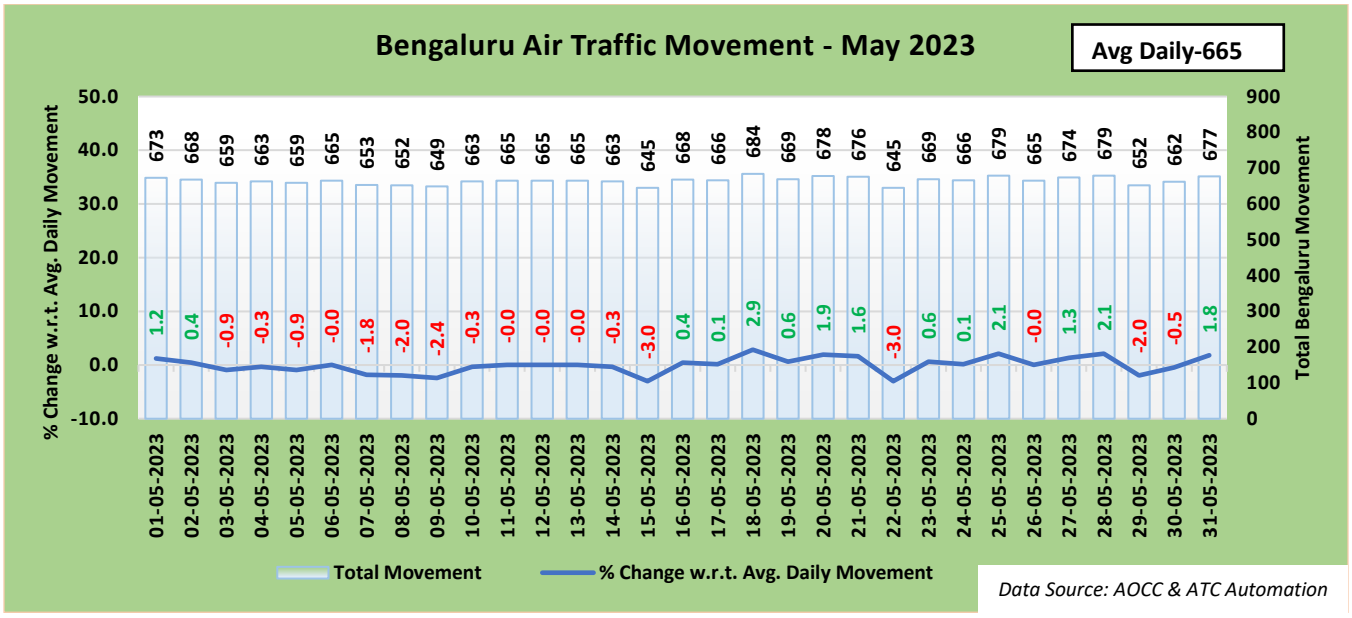

Figure 5: Air Traffic Movement for Bengaluru – May 2023

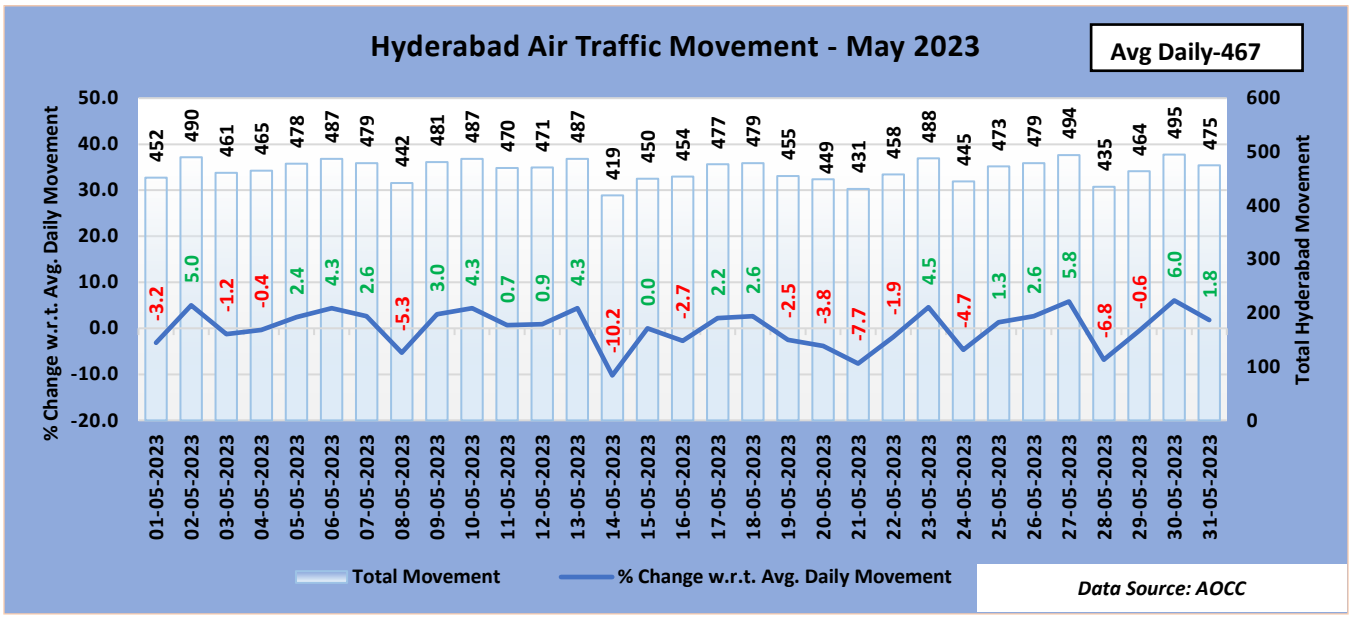

Figure 6: Air Traffic Movement for Hyderabad - May 2023

It can be concluded from the above charts that on month end(31st May 2023) the ATMs at Delhi, Mumbai, Bengaluru and Hyderabad saw an increase of 0.9%, 4.7%, 1.8% and 1.8% respectively in comparison to the average daily movement in the month of May'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 May 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.

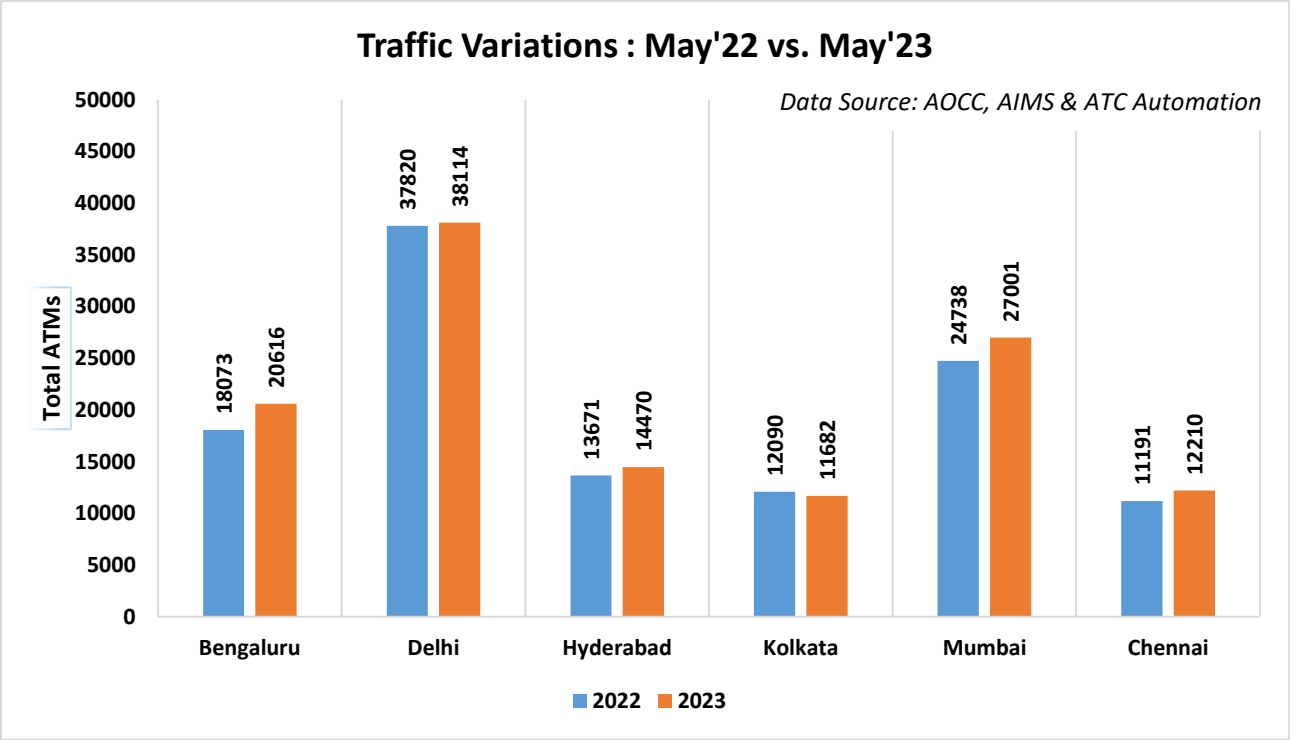

Figure 7: Traffic Variation (YoY)

III. Flight Operations – Airlinewise

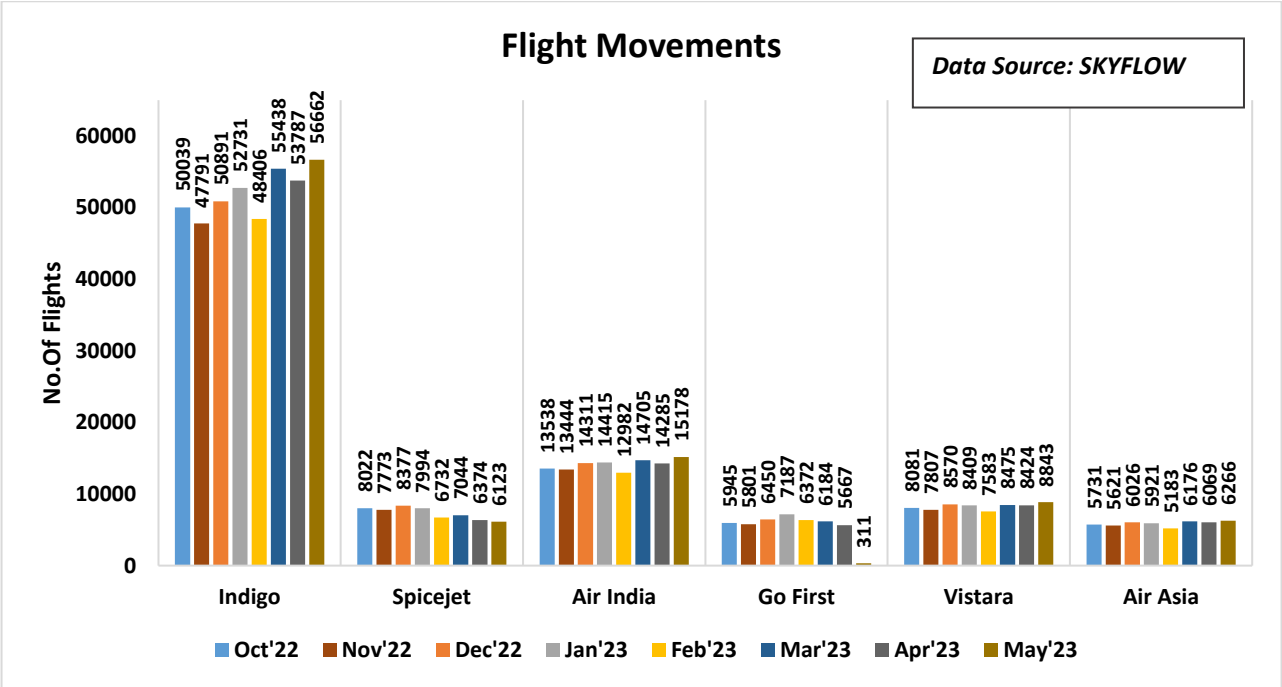

Figure 8: Flight Movements –Airlinewise

Inference:

1. Indigo, Air India, Vistara, and Air Asia Airlines have recorded a higher monthly average Flight movement in May'23 as compared to Apr'23 whereas Spicejet saw a marginal decline while Go first stopped operations from 03rd May 2023.

C. ATFM Post Operations – CDM Analysis

I. Introduction

Analysis Period **1st – 31st May 23**

Back Ground During the above mentioned period, **Five (05)** ATFM measures were applied **for Delhi 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:–

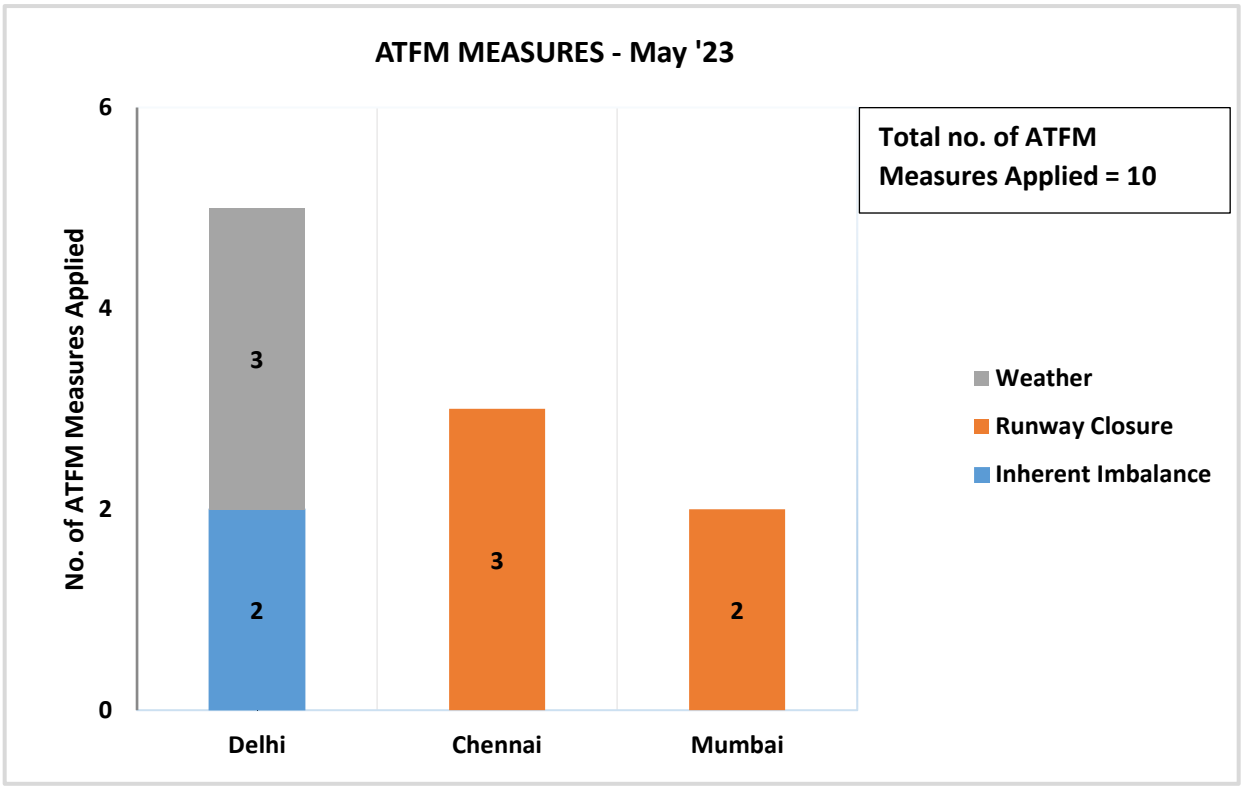

Figure 9: ATFM Measures –May'23

II. ATFM Measures Overview

Constrained Airport	Delhi	Mumbai	Chennai
Number of ATFM measures applied	5	2	3
Average ATFM Ground delay(in min) due to measures*	22.1	20.2	14.6
Maximum ATFM Ground delay(in min) due to measures	58	32	30
% Compliance	71.3	89.3	87.2

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

Total Arrivals	516
Total International Arrivals(exempted)	85
Total affected flights in scenario (Domestic Arrivals)	431
Total Domestic Arrivals with zero ATFM delay	48
Total Domestic Arrivals with ATFM delay	383

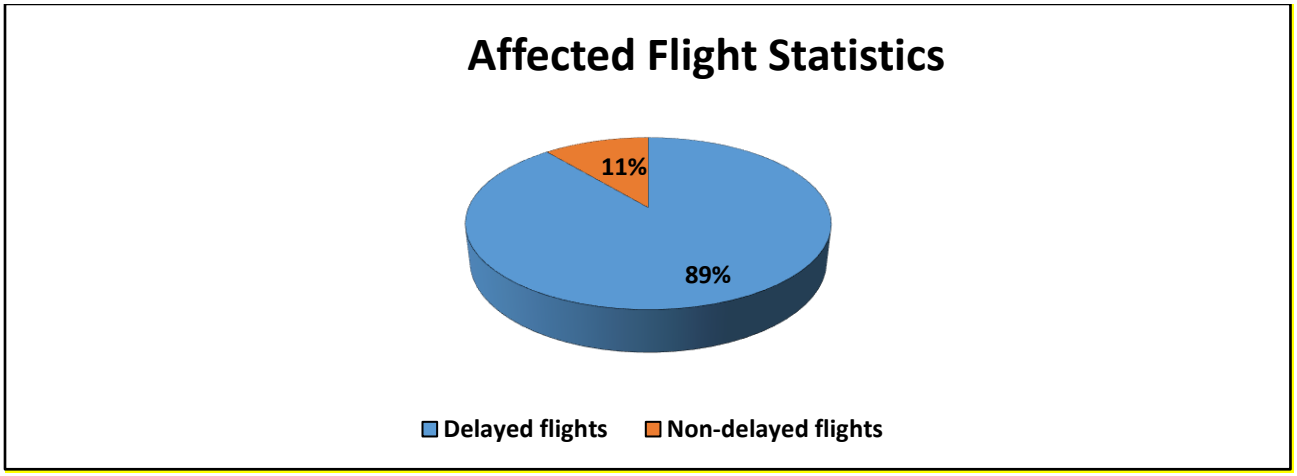

Figure 10: Affected Flight Statistics –May'23

III. Overall Compliance

Total arrivals	516
Domestic arrivals	431
Flights with complete data (ATOT)	409
Flights with incomplete data	11
Flights Not Operated	11
Compliant*	308
Non-Compliant	101

*Total No. of Revised CTOTs issued = 81 (Compliance calculation for flights which were issued revised CTOT is w.r.t. new CTOT issued)

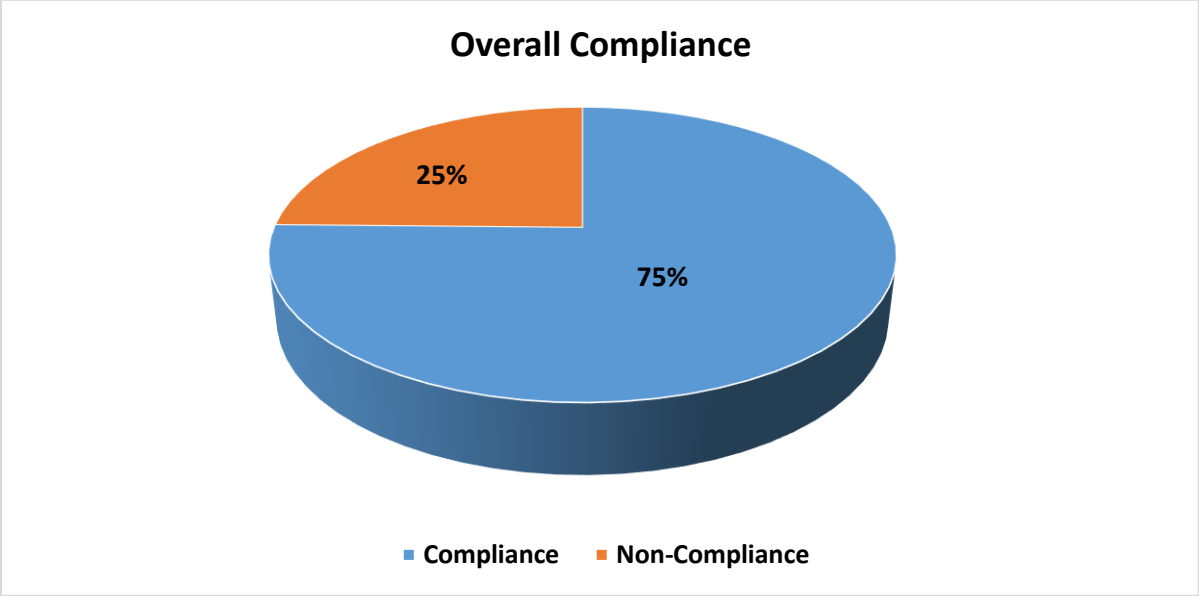

***Figure 11*: Overall Compliance – May'23**

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

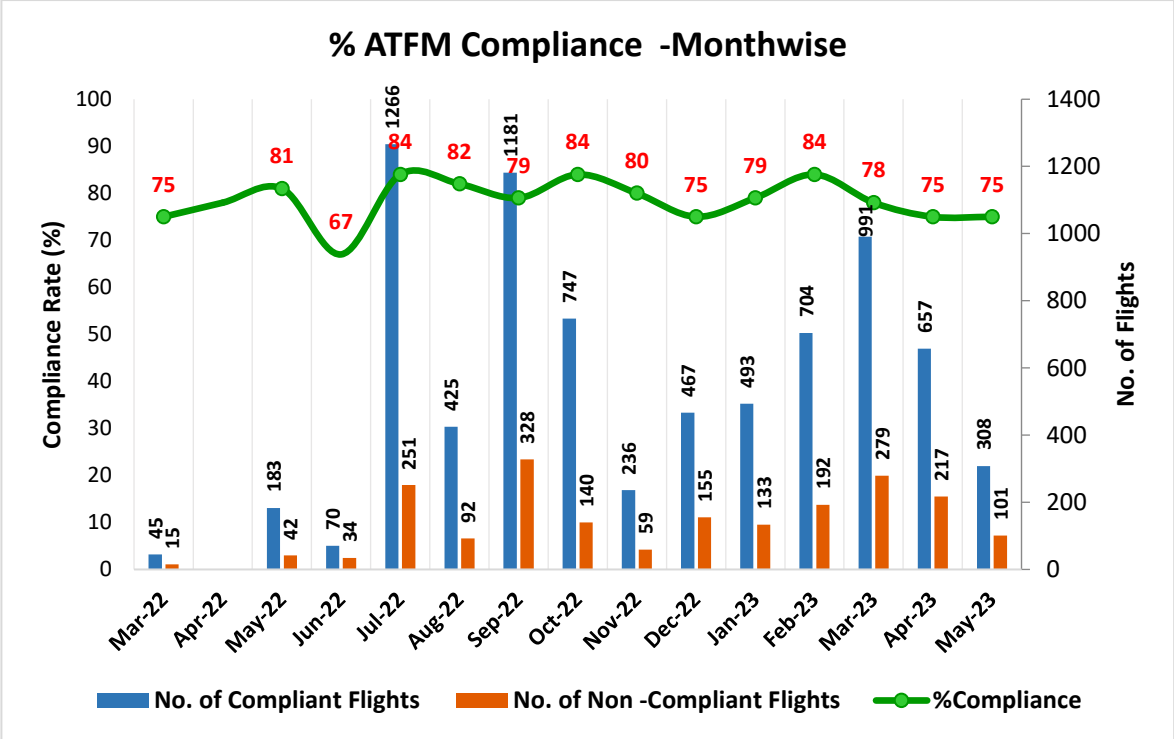

Figure 12: Compliance(Monthwise)

Inference

1. Out of the total arrivals captured(516 flights) during the CDM scenario for the constrained Airports, 83.5% of flights i.e. domestic arrivals(431 flights) were candidates for ground delay(participating).
2. Out of these Domestic Arrivals, 89% (383 flights)are assigned ATFM ground delay.
3. Out of the total arrivals captured(516 flights) to the constrained Airport during the ATFM scenario, only 74% of flights(383 flights) were assigned ATFM Ground Delay.

IV. CTOT Compliance rate – Airportwise

MUMBAI FIR (78%)*	Compliant	Non Compliant	% Compliant
Ahmedabad	8	2	80%
Aurangabad	1	0	100%
Mumbai	24	2	92%
Vadodara	3	1	75%
Bhopal	4	0	100%
Indore	4	2	67%
Jabalpur	2	0	100%
Jamnagar	1	0	100%
Kandla	1	1	50%
Nagpur	4	2	67%
Pune	7	8	47%
Rajkot	5	1	83%
Shirdi	3	0	100%
Surat	4	0	100%
Udaipur	1	1	50%
KOLKATA FIR (73%)*	**Compliant**	**Non Compliant**	**% Compliant**
Prayagraj	2	1	67%
Siliguri	5	1	83%
Varanasi	6	2	75%
Bhubaneswar	7	2	78%
Kolkata	17	9	65%
Durgapur	2	2	50%
Darbhanga	1	0	100%
Gorakhpur	0	1	0%
Guwahati	14	3	82%
Imphal	0	1	0%
Jharsuguda	0	2	0%
Kushinagar	3	0	100%
Khajuraho	1	0	100%
Dibrugarh	2	0	100%
Patna	11	1	92%
Ranchi	6	2	75%
Raipur	3	2	60%

DELHI FIR (68%)*	Compliant	Non Compliant	% Compliant
Amritsar	3	2	60%
Chandigarh	7	3	70%
Dehradun	7	1	88%
Delhi	9	2	82%
Gwalior	0	1	0%
Jodhpur	3	1	75%
Jaipur	3	5	38%
Jammu	0	1	0%
Leh	0	1	0%
Lucknow	11	3	79%
Srinagar	10	5	67%
CHENNAI FIR (79%)*	Compliant	Non Compliant	% Compliant
Bangalore	19	9	68%
Vijayawada	0	1	0%
Coimbatore	8	1	89%
Kochi	11	0	100%
MOPA Goa	5	1	83%
Goa	10	4	71%
Hubli	1	0	100%
Hyderabad	17	3	85%
Begumpet Hyderabad	1	0	100%
Kurnool	3	0	100%
Madurai	5	0	100%
Mangalore	2	0	100%
Chennai	12	1	92%
Mysore	1	0	100%
Port Blair	0	2	0%
Sindhudurg	0	1	0%
Tuticorin	3	0	100%
Thiruvananthapuram	5	1	83%
Visakhapatnam	0	3	0%

**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 – Airlinewise

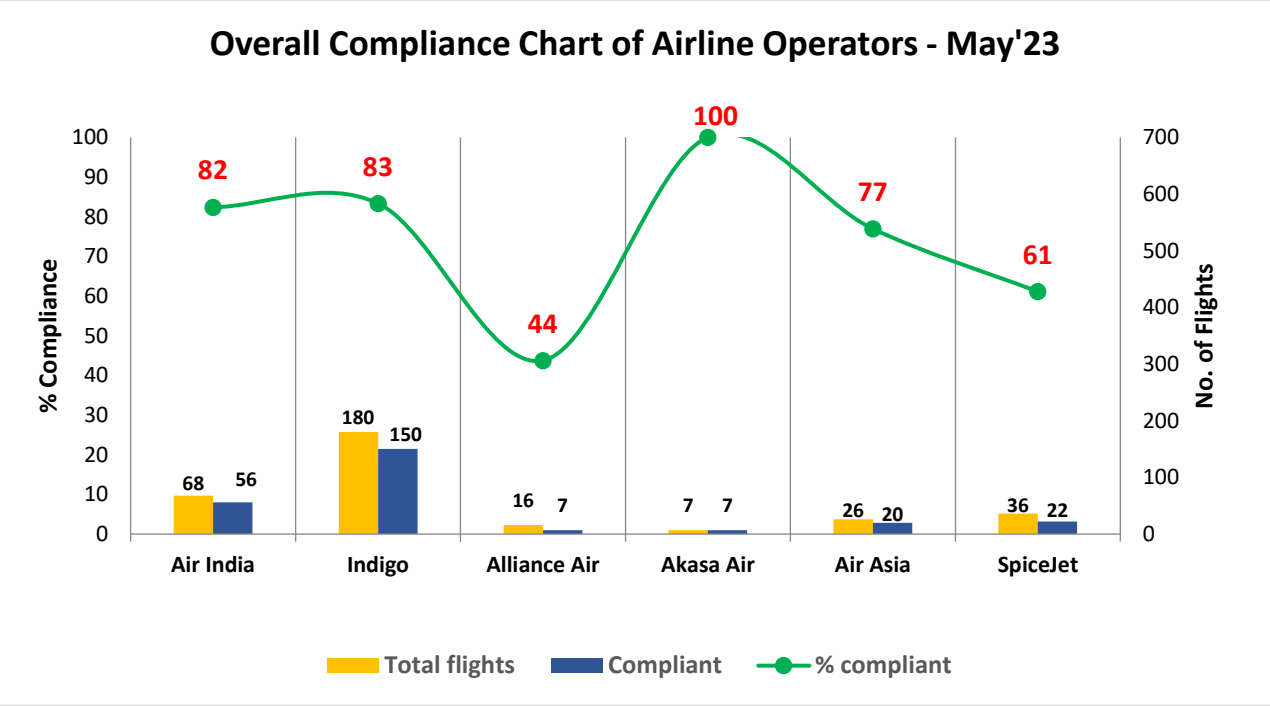

Figure 13: Airline wise Compliance –May'23

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 79% whereas Delhi region has the lowest compliance rate of 68%.

3. Air India,Indigo, Akasa Air, and Air Asia Airlines have a CTOT compliance higher than the average recorded compliance for the month of May'23.

VI. Reason For Non Compliance

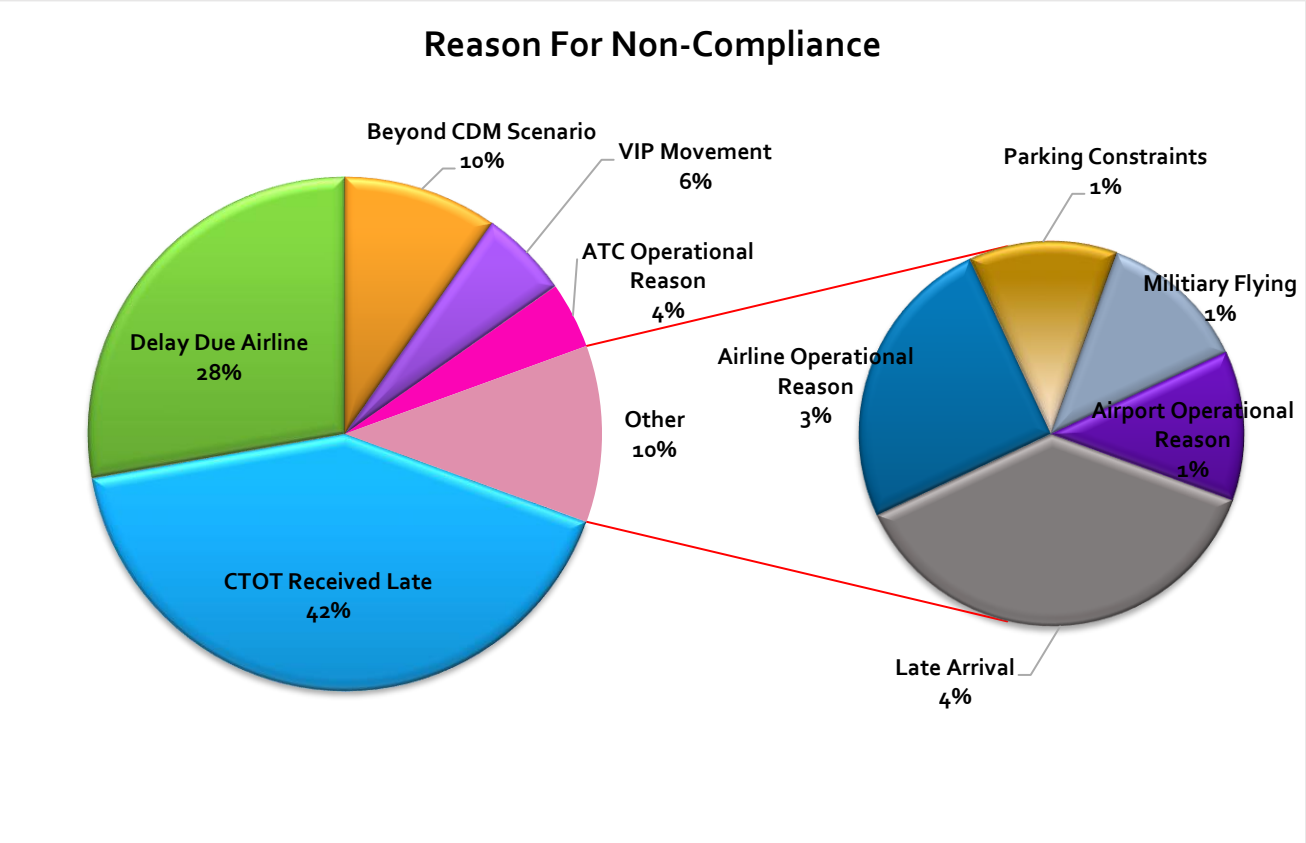

Figure 14: Reason for Non-Compliance as provided by FMPs

Inference:

1. 42 % 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. ATFM measures due to weather were initiated at short notice resulting in delay in dissemination of CTOTs.

2. 28% of the CTOT Non- compliance was reported to be because of delay due airlines.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 and Chennai was 6.6, 10.8 and 10.2 minutes respectively.

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

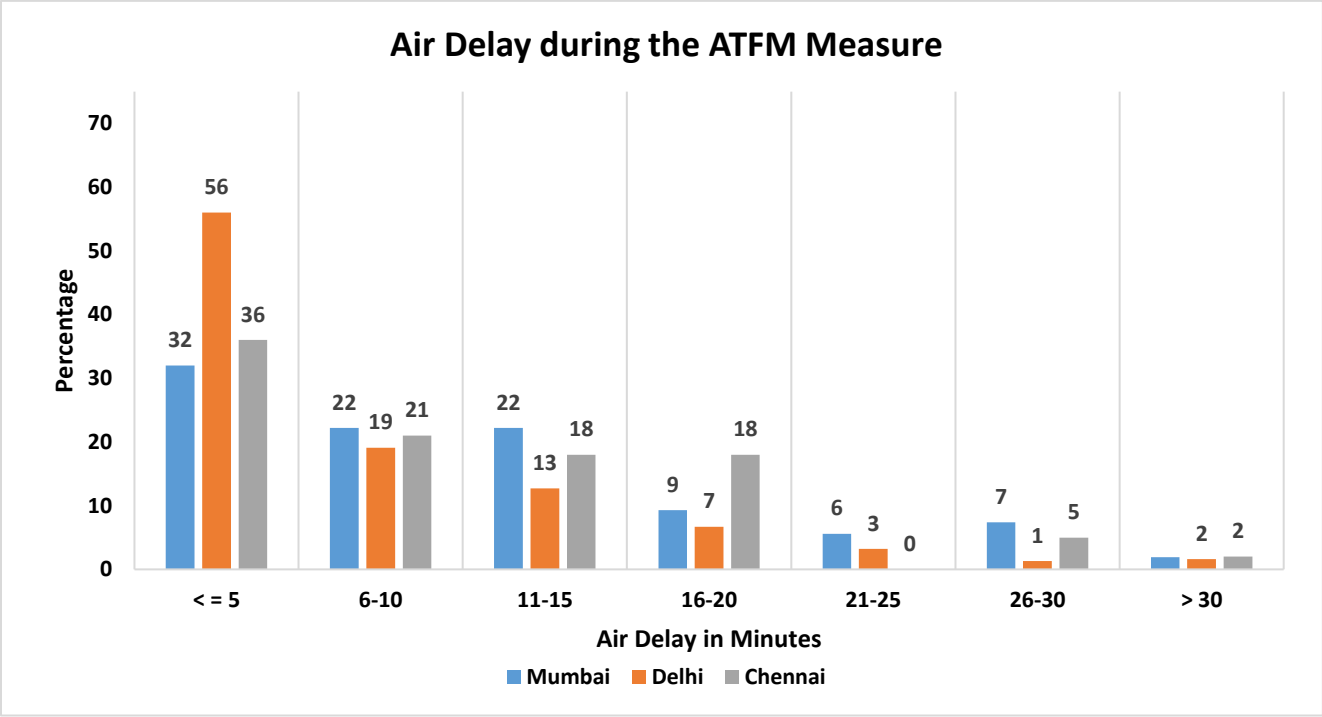

Figure 15: Air Delay distribution during the CDM period

Inference

1. 54% 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. 57% 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 = ∑ (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) = **∑ (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)= 2925 mins

Total Air Delay (with no ATFM measures) = 6976 mins

Reduction in Air delay due to ATFM measures= (6976-2925) = **4051 mins**

Fuel Saving Calculation:

Total Fuel saved during the ATFM Measure: **2,10,577.76 Kg**

Total reduction in CO_2 emission : 3.16(KgCO_2/kg fuel) **2,10,577.76 Kg** ***= 665425.72 Kg***

**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**
Affected Flight statistics	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)
Average ATFM delay	$\frac{\boldsymbol{Total\ monthly\ ATFM\ delay\ (in\ minutes)}}{\boldsymbol{Total\ Domestic\ Arrivals}}$
Maximum ATFM delay	Maximum ATFM delay (in minutes) assigned in the month
Overall compliance rate	Defined as monthly ATFM departure slot adherence rate of regulated flights. Flights having ATOT within theATFM Slot Tolerance Window (STW) of minus 5 to plus 10 minutes of CTOTs, are considered as compliant flights
CTOT Compliance rate of Airline operators	An overview of CTOT compliance rate of various Airline operators
CTOT Compliance rate of Airports within different Regions	An overview of CTOT compliance rate of Airports within 4 FIRs
Air delay statistics	Air delay defined as difference between AET & EET, whereAET(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** Average Air Delay is calculated as: $\boldsymbol{Average\ Air\ Delay} = \frac{\boldsymbol{Total\ Air\ Delay\ to\ domestic\ arrivals\ (with\ values\ greater\ than\ zero)}}{\boldsymbol{Total\ Domestic\ Arrivals}}$ *CLDT: Calculated Landing Time* *CTOT: Calculated Take off Time* *ALDT: Actual Landing Time* *ATOT: Actual Take off Time*