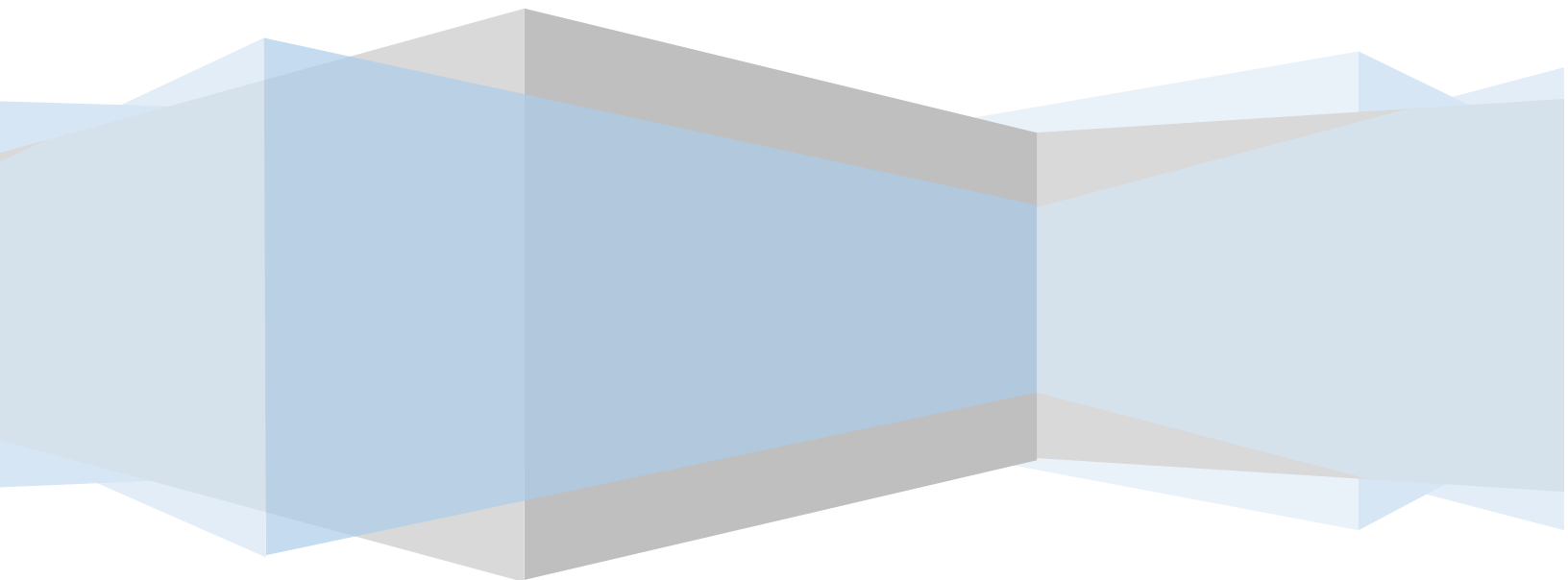


# POST OPERATIONS ANALYSIS REPORT

March, 2023

CENTRAL COMMAND CENTER, C-ATFM, DELHI







# Contents

<b>A. Executive Summary .....</b>	<b>4</b>
<b>B. Traffic Analysis .....</b>	<b>5</b>
<b>I. Air Traffic Movement at Major Airports in India .....</b>	<b>5</b>
<b>II. Comparison of total ATMs (YoY) and Monthwise .....</b>	<b>8</b>
<b>III. Flight Operations – Airlinewise .....</b>	<b>9</b>
<b>C. ATFM Post Operations – CDM Analysis.....</b>	<b>10</b>
<b>I. Introduction .....</b>	<b>10</b>
<b>II. ATFM Measures Overview.....</b>	<b>11</b>
<b>III. Overall Compliance .....</b>	<b>12</b>
<b>IV. CTOT Compliance rate – Airportwise .....</b>	<b>14</b>
<b>VI. Reason For Non Compliance.....</b>	<b>18</b>
<b>VII. Air Delay during the CDM Scenario period .....</b>	<b>19</b>
<b>VIII. Tangible Benefits due to ATFM Measures .....</b>	<b>20</b>
<b>D. Glossary .....</b>	<b>22</b>



## List of Figures

Figure 1: Monthly Traffic Growth.....	4
Figure 2: Average Daily Movements(Feb'23 vs Mar'23) .....	5
Figure 3: Air Traffic Movement for Delhi –March 2023 .....	6
Figure 4: Air Traffic Movement for Mumbai - March 2023 .....	6
Figure 5: Air Traffic Movement for Bengaluru – March 2023 .....	7
Figure 6: Air Traffic Movement for Hyderabad - March 2023 .....	7
Figure 7: Traffic Variation (YoY) .....	8
Figure 8: Flight Movements –Airlinewise .....	9
Figure 9: ATFM Measures –March'23 .....	10
Figure 10: Affected Flight Statistics –Mar'23 .....	11
Figure 11: Overall Compliance – Mar'23.....	12
Figure 12: Compliance(Monthwise) .....	13
Figure 13: Airline wise Compliance –Mar'23 .....	17
Figure 14: Reason for Non-Compliance as provided by FMPs .....	18
Figure 15: Air Delay distribution during the CDM period.....	19



## A. Executive Summary

Domestic air traffic has recorded a growth of 35.4 % whereas the international air traffic declined by 26.0 % in the month of March'23 as compared to February'23.

On average, the Indian Airports in the ATFCM area saw 4801 IFR flights per day in the month of March 2023. The peak day was on 20<sup>th</sup> March 2023 (5113 IFR flights). Monday's were the busiest days throughout this month with an average of 4186 domestic IFR flights per day.

Total twenty four (24) ATFM measures were applied this month during periods of congestion at Delhi and Mumbai Airport.

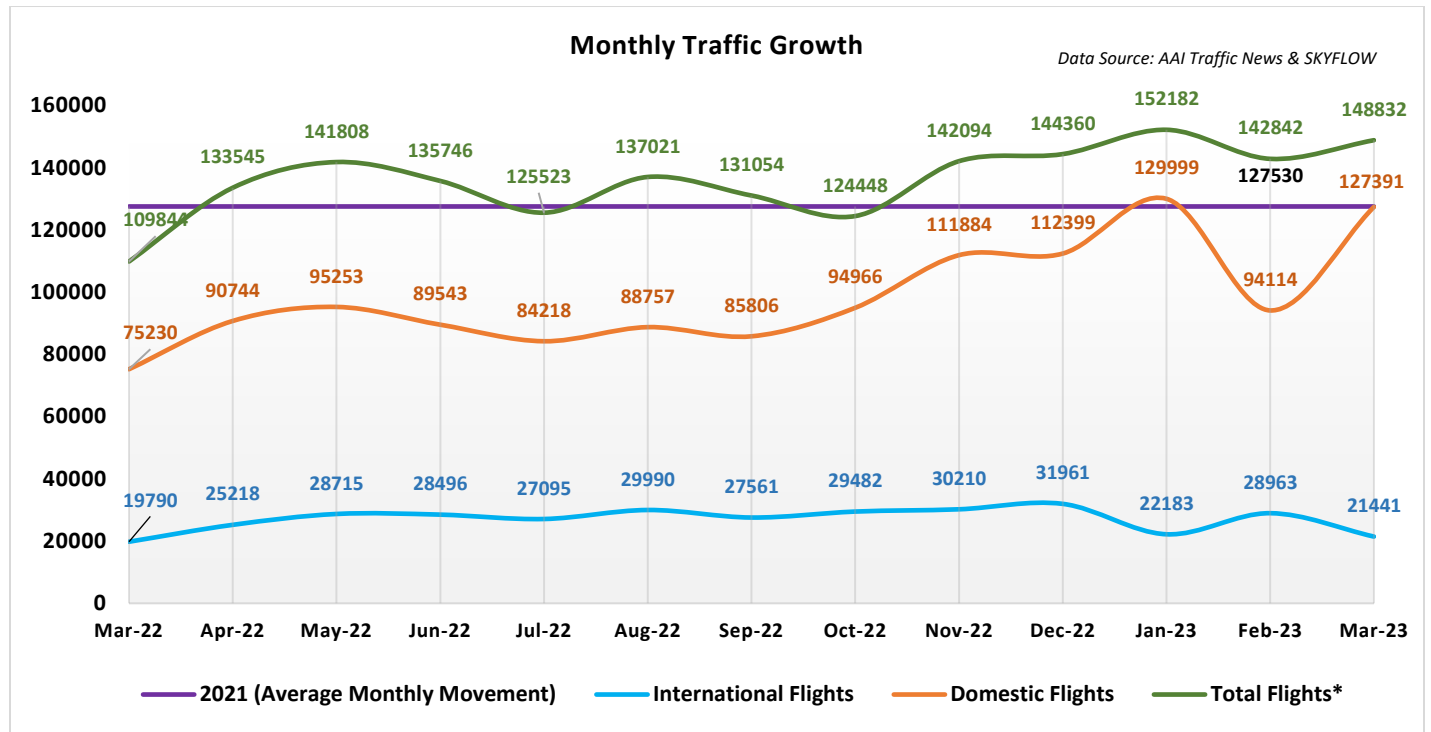


Figure 1: Monthly Traffic Growth

\*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 (Mar'2022 to Mar'2023).



## B. Traffic Analysis

### I. Air Traffic Movement at Major Airports in India

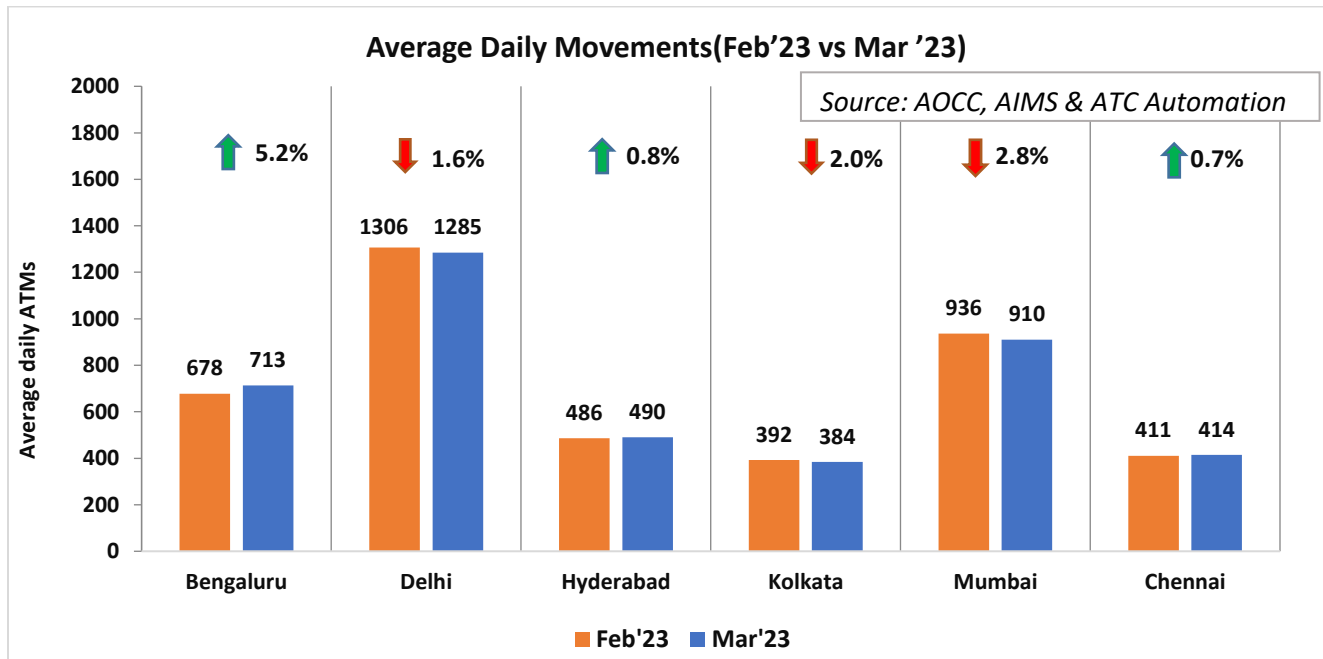


Figure 2: Average Daily Movements(Feb'23 vs Mar'23)

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

Airports\Year	Avg. Daily ATMs (YoY) for six major airports				
	Jan'20	Mar'20	Mar'21	Mar'22	Mar'23
Bengaluru	681	463	529	494	713
Delhi	1363	912	1185	1025	1285
Hyderabad	546	366	399	353	490
Kolkata	499	351	357	331	384
Mumbai	899	580	723	577	910
Chennai	506	338	327	311	414



Major Airports - Bengaluru ,Delhi, Hyderabad, Kolkata, Mumbai and Chennai Airport recorded average daily movements 105%,94%,90%,77%,101% and 82% respectively of that January 2020 levels(considered here as Pre-Covid level).

Air Traffic Movement for each day in Mar'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.

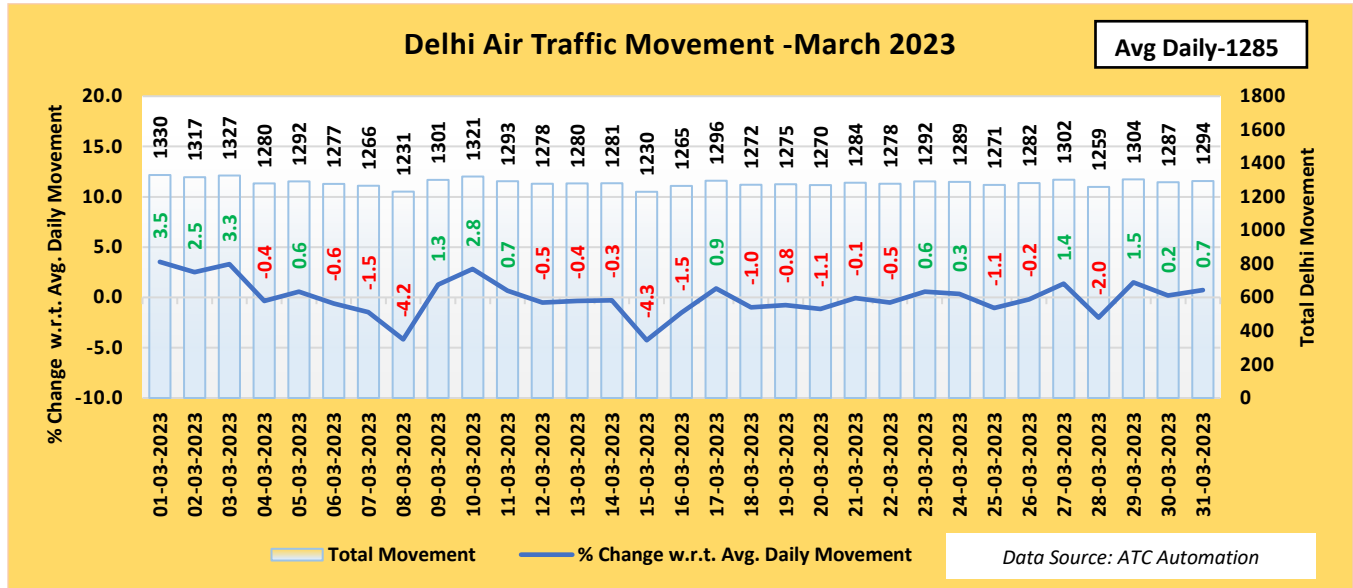


Figure 3: Air Traffic Movement for Delhi –March 2023

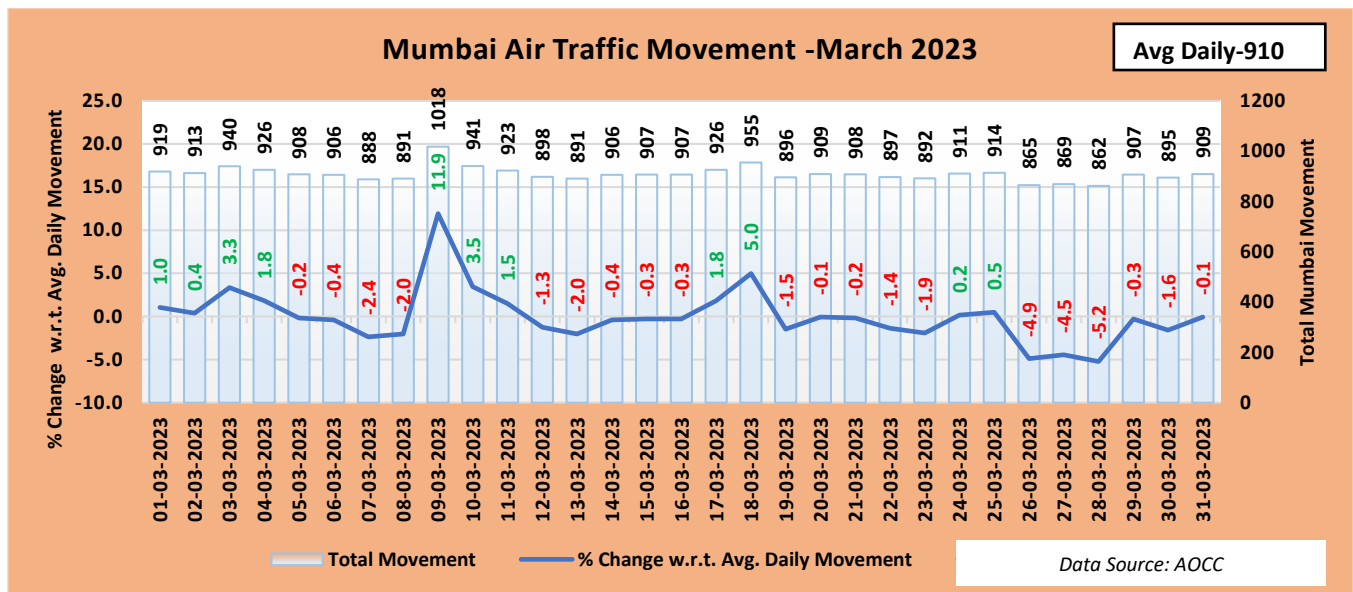


Figure 4: Air Traffic Movement for Mumbai - March 2023

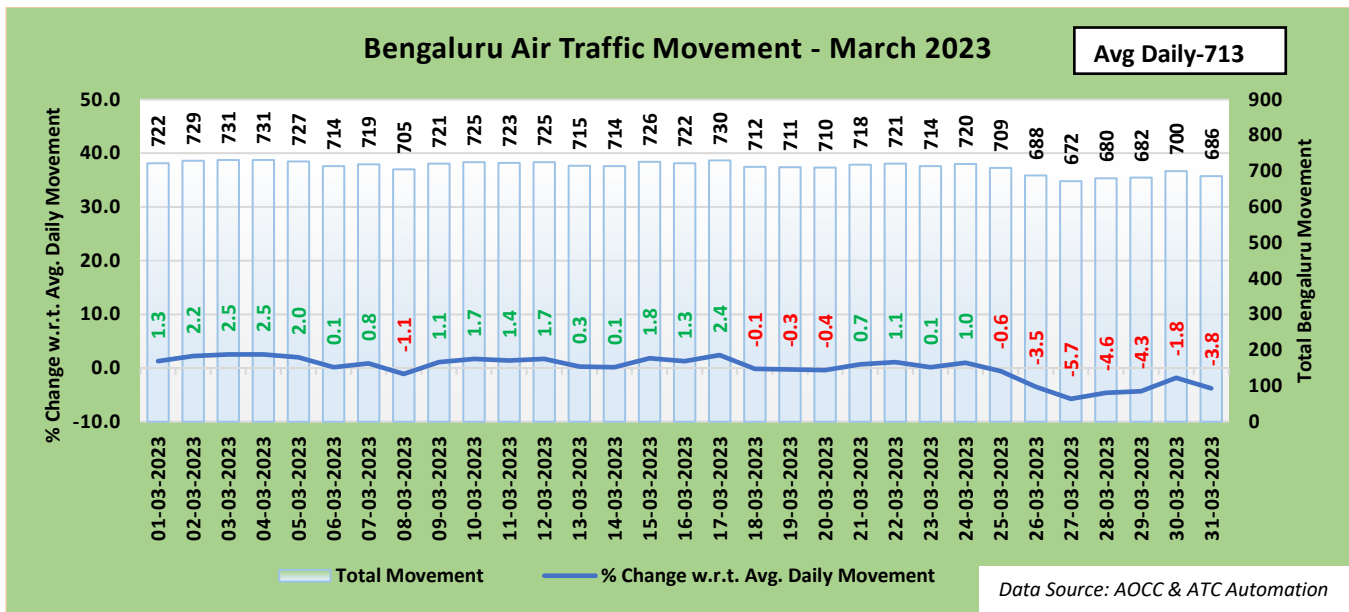


Figure 5: Air Traffic Movement for Bengaluru – March 2023

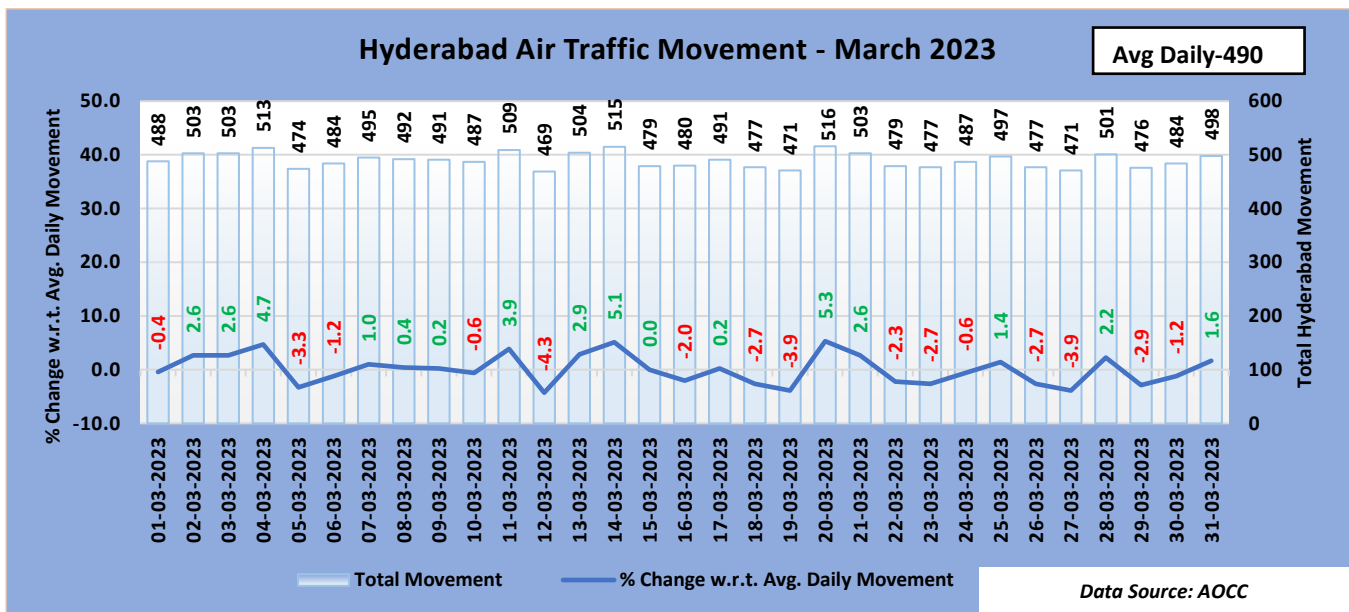


Figure 6: Air Traffic Movement for Hyderabad - March 2023

It is evident from the above charts that on month end(31st March 2023) the ATMs at Delhi and Hyderabad saw an increase of 0.7% and 1.6% respectively & Mumbai and Bengaluru saw decline of 0.1% and 3.8% respectively as compared to the average daily movement for the month of March'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 March 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.

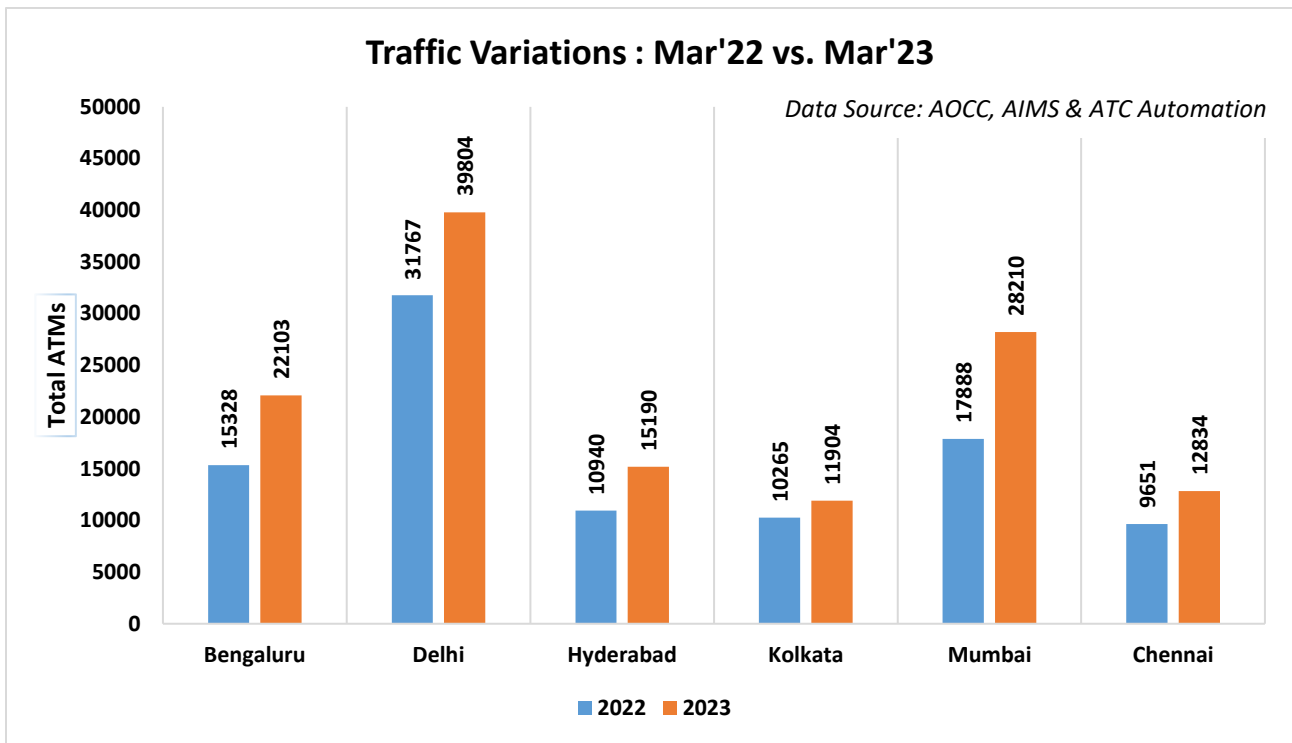


Figure 7: Traffic Variation (YoY)



### III. Flight Operations – Airlinewise

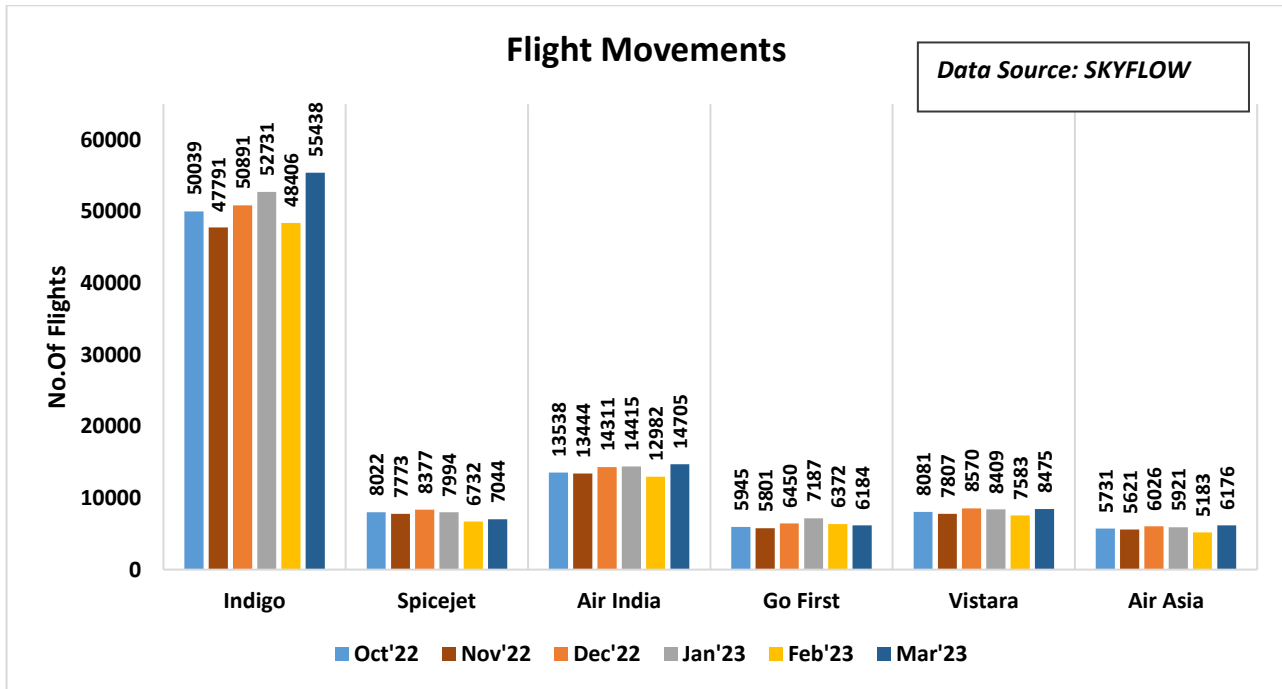


Figure 8: Flight Movements –Airlinewise

**Inference:**

1. Indigo, Air India, Spicejet, Vistara and Air Asia Airlines have recorded higher Flight movements in Mar’23 as compared to Feb’23.
2. Go First Airlines have recorded lesser flights in Mar’23 as compared to Feb’23.



## C. ATFM Post Operations – CDM Analysis

### I. Introduction

**Analysis Period** 1<sup>st</sup> – 31<sup>st</sup> March 23

**Back Ground** During the above mentioned period, **Twenty Two (22)** ATFM measures were applied for **Delhi Airport** and **Two (02)** ATFM measures were applied for **Mumbai Airport** due to the following reasons as illustrated in the bar chart below:–

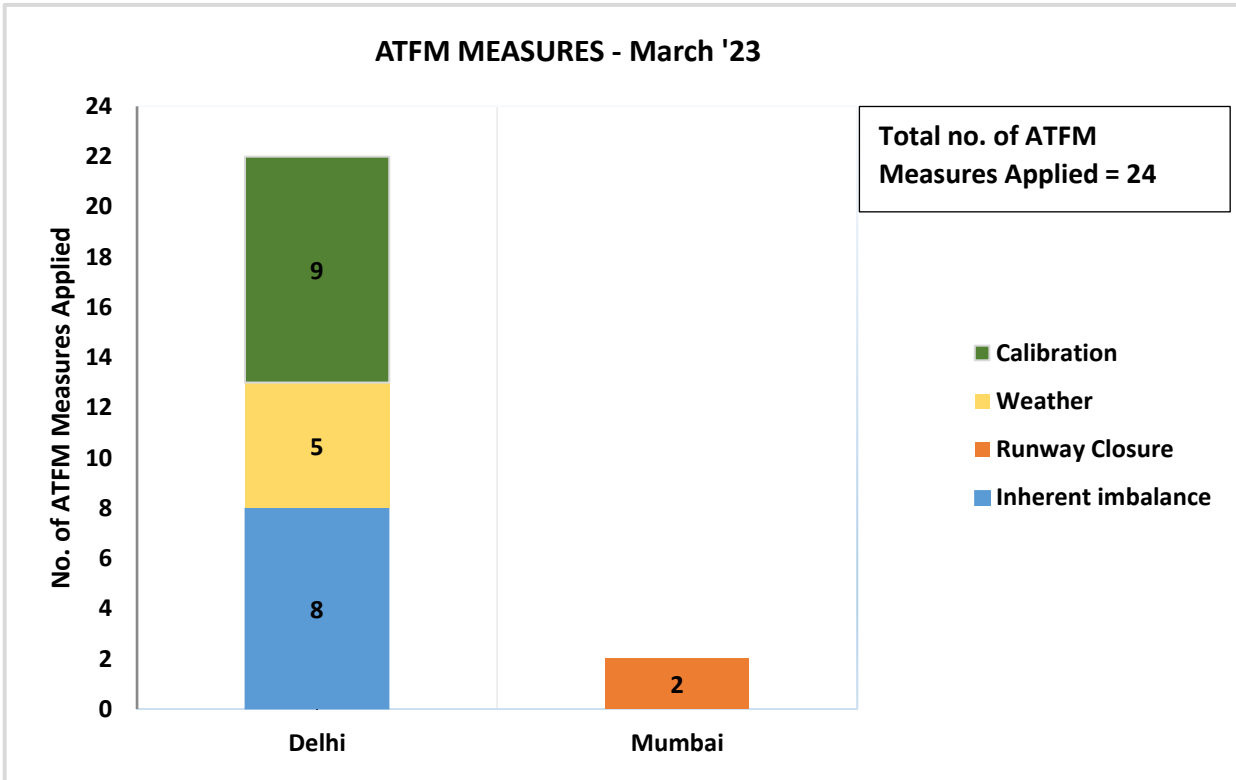


Figure 9: ATFM Measures –March'23



## II. ATFM Measures Overview

Constrained Airport	Delhi Airport	Mumbai Airport
Number of ATFM measures applied	22	2
Average ATFM Ground delay(in min) due to measures*	14.6	13.6
Maximum ATFM Ground delay(in min) due to measures	61	25
% Compliance	77.5	88.3

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

Total Arrivals	1574
Total International Arrivals(exempted)	271
Total affected flights in scenario (Domestic Arrivals)	1303
Total Domestic Arrivals with zero ATFM delay	143
Total Domestic Arrivals with ATFM delay	1160

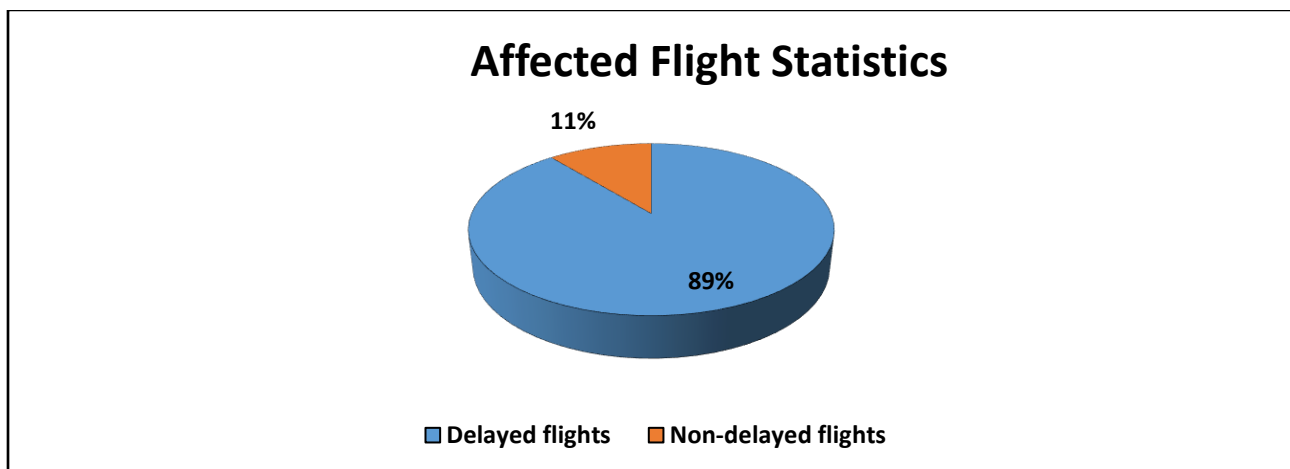


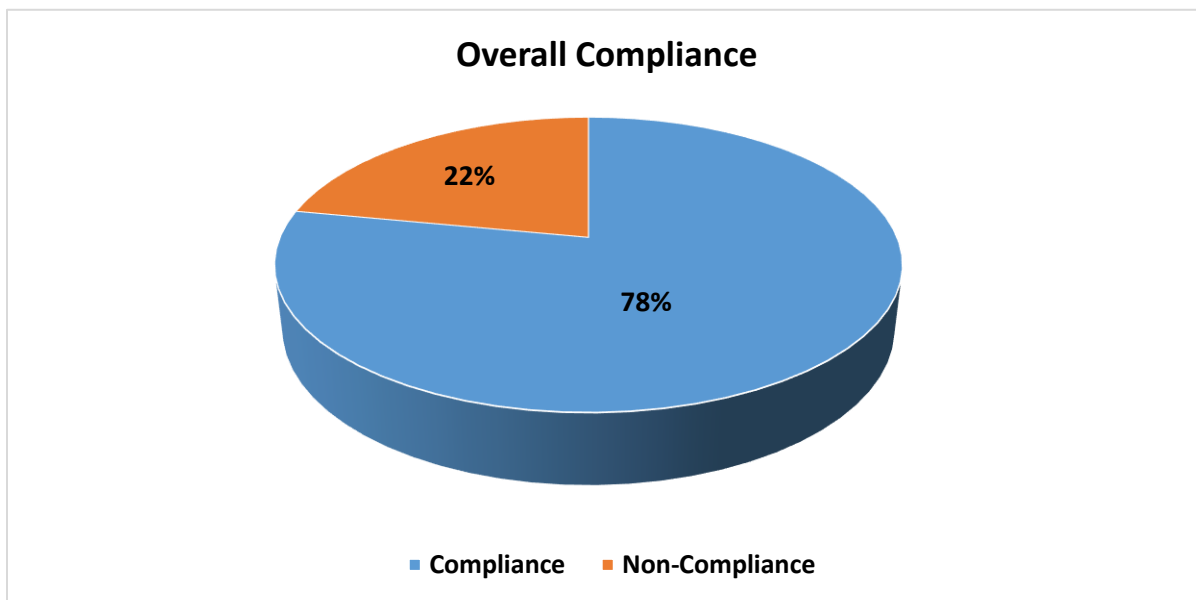
Figure 10: Affected Flight Statistics –Mar'23



### III. Overall Compliance

<b>Total arrivals</b>	1574
<b>Domestic arrivals</b>	1303
<b>Flights with complete data (ATOT)</b>	1270
<b>Flights with incomplete data</b>	8
<b>Flights Not Operated</b>	25
<b>Compliant*</b>	991
<b>Non-Compliant</b>	279

\*Total No. of Revised CTOTs issued = 219 (Compliance calculation for flights which were issued revised CTOT is w.r.t. new CTOT issued)



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

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

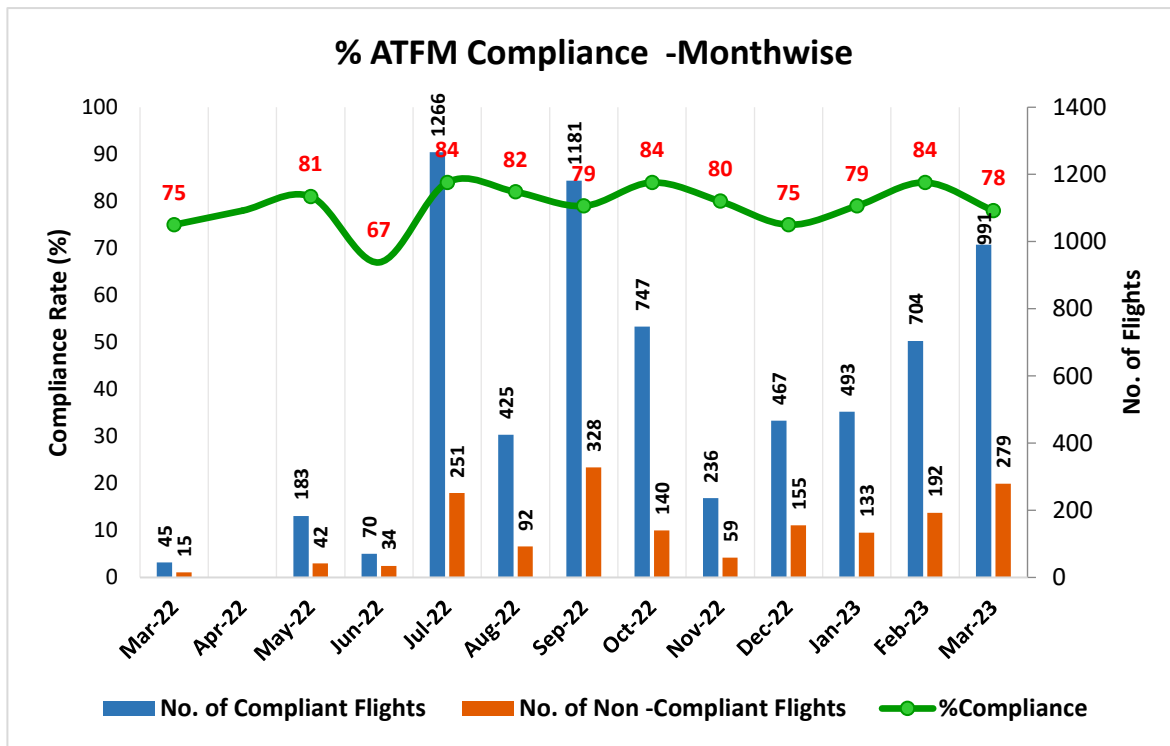


Figure 12: Compliance(Monthwise)

### Inference

1. Out of the total arrivals captured(1574 flights) during the CDM scenario for the constrained Airports, 83% of flights i.e. domestic arrivals(1303 flights) were candidates for ground delay(participating).
2. Out of these Domestic Arrivals, 89% (1160 flights )are assigned ATFM ground delay.
3. Out of the total arrivals captured(1574 flights) to the constrained Airport during the ATFM scenario, only 74% of flights(1160 flights) were assigned ATFM Ground Delay.



## IV. CTOT Compliance rate – Airportwise

<b>MUMBAI FIR (78%)*</b>	<b>Compliant</b>	<b>Non Compliant</b>	<b>% Compliant</b>
Ahmedabad	20	7	74%
Aurangabad	6	2	75%
Mumbai	89	22	80%
Bhuj	1	0	100%
Vadodara	3	2	60%
Bhopal	14	0	100%
Indore	11	1	92%
Jabalpur	2	0	100%
Jamnagar	2	0	100%
Kandla	0	1	0%
Nagpur	12	3	80%
Nasik	1	1	50%
Pune	31	15	67%
Rajkot	11	3	79%
Shirdi	12	4	75%
Surat	5	2	71%
Udaipur	14	3	82%
<b>KOLKATA FIR (79%)*</b>	<b>Compliant</b>	<b>Non Compliant</b>	<b>% Compliant</b>
Prayagraj	6	1	86%
Agartala	2	0	100%
Siliguri	27	6	82%
Shillong	0	1	0%
Varanasi	16	5	76%
Bhubaneswar	14	3	82%
Kolkata	52	12	81%
Chakeri	3	0	100%
Durgapur	7	2	78%
Darbhanga	2	3	40%
Deoghar	3	0	100%
Gorakhpur	7	3	70%
Guwahati	37	13	74%
Gaya	1	0	100%
Imphal	1	0	100%
Jharsuguda	1	1	50%



Jagdalpur	1	0	100%
Kushinagar	1	1	50%
Khajuraho	6	1	86%
Aizawl	1	0	100%
Dibrugarh	11	1	92%
Dimapur	1	1	50%
Patna	40	5	89%
Ranchi	14	7	67%
Raigarh	0	1	0%
Raipur	8	1	89%
<b>DELHI FIR (71%)*</b>	<b>Compliant</b>	<b>Non Compliant</b>	<b>% Compliant</b>
Agra	0	3	0%
Amritsar	11	1	92%
Awantipur Air Force Station	1	1	50%
Adampur	1	0	100%
Bikaner	5	2	71%
Beas	0	1	0%
Chandigarh	25	6	81%
Dehradun	19	6	76%
Delhi	6	1	86%
Hindon	0	1	0%
Kangra	11	0	100%
Gwalior	4	1	80%
Halwara Air Force Station	0	1	0%
Jodhpur	6	4	60%
Jaipur	12	3	80%
Jaisalmer	1	0	100%
Jammu	13	10	57%
Leh	22	7	76%
Lucknow	32	8	80%
Pathankot	0	1	0%
Pantnagar	2	2	50%
Suratgarh	1	1	50%
Shimla	4	0	100%
Srinagar	41	27	60%





CHENNAI FIR (83%)*	Compliant	Non Compliant	% Compliant
Hal Bangalore	1	1	50%
Bangalore	64	11	85%
Vijayawada	2	4	33%
Coimbatore	14	1	93%
Kochi	33	4	89%
MOPA Goa	9	5	64%
Goa	29	12	71%
Hubli	3	0	100%
Hyderabad	54	3	95%
Begumpet Hyderabad	1	0	100%
Madurai	6	1	86%
Mangalore	2	0	100%
Chennai	51	9	85%
Port Blair	0	2	0%
Sindhudurg	1	0	100%
Thiruvananthapuram	4	1	80%
Visakhapatnam	4	1	80%

*\*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(78%) for the month are highlighted in red.*



### V. CTOT Compliance rate – Airlinewise

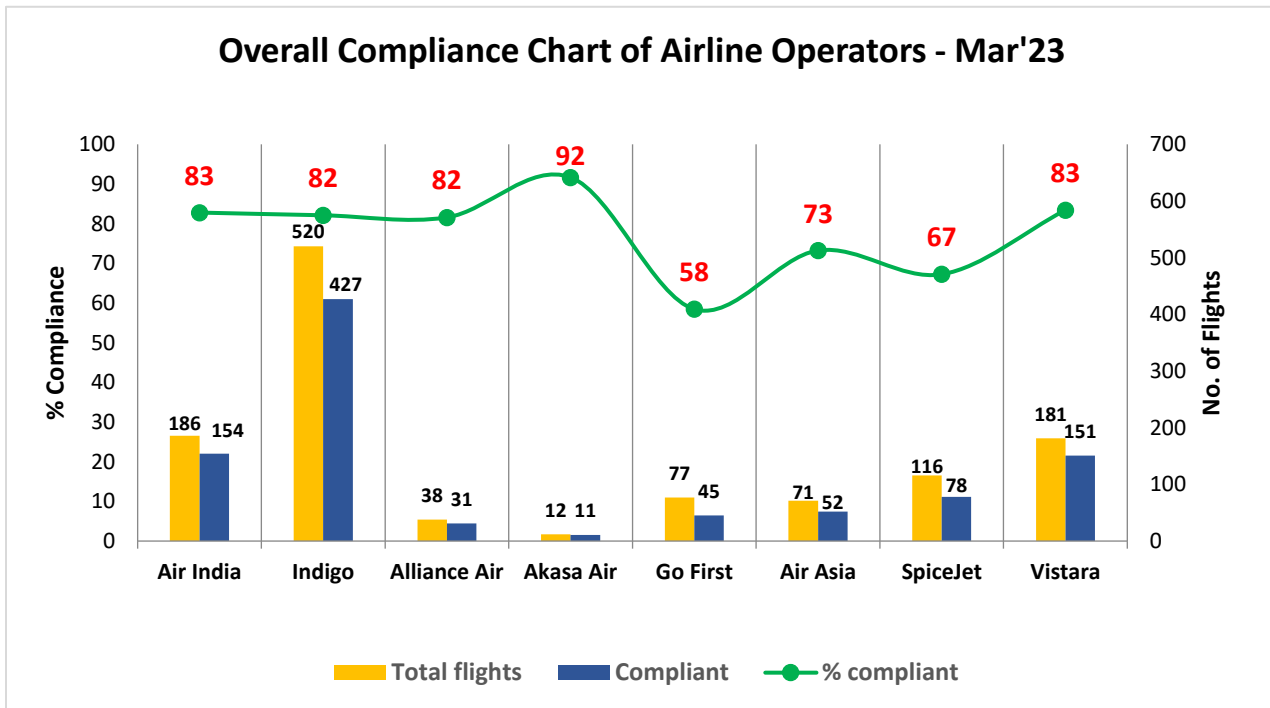
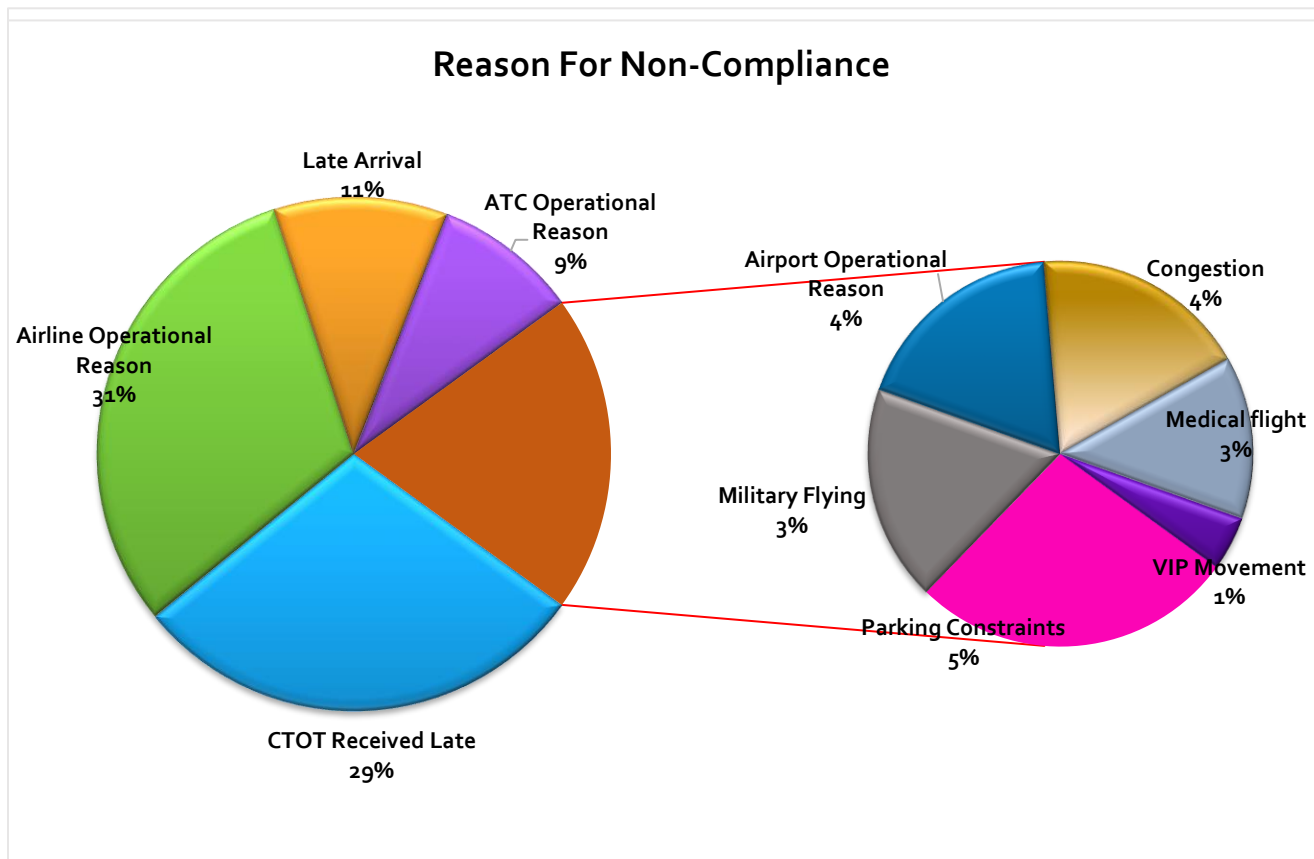


Figure 13: Airline wise Compliance –Mar’23

#### Inference

1. Out of the total domestic arrivals with complete data in the CDM scenario, 78% arrivals are compliant.
2. Chennai region has the highest compliance rate of 83% whereas Delhi region has the lowest compliance rate of 71%.
3. Indigo, Akasa Air, Air India, Alliance Air and Vistara Airlines have a CTOT compliance higher than the average recorded compliance for the month of Mar’23.

## VI. Reason For Non Compliance



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

### Inference:

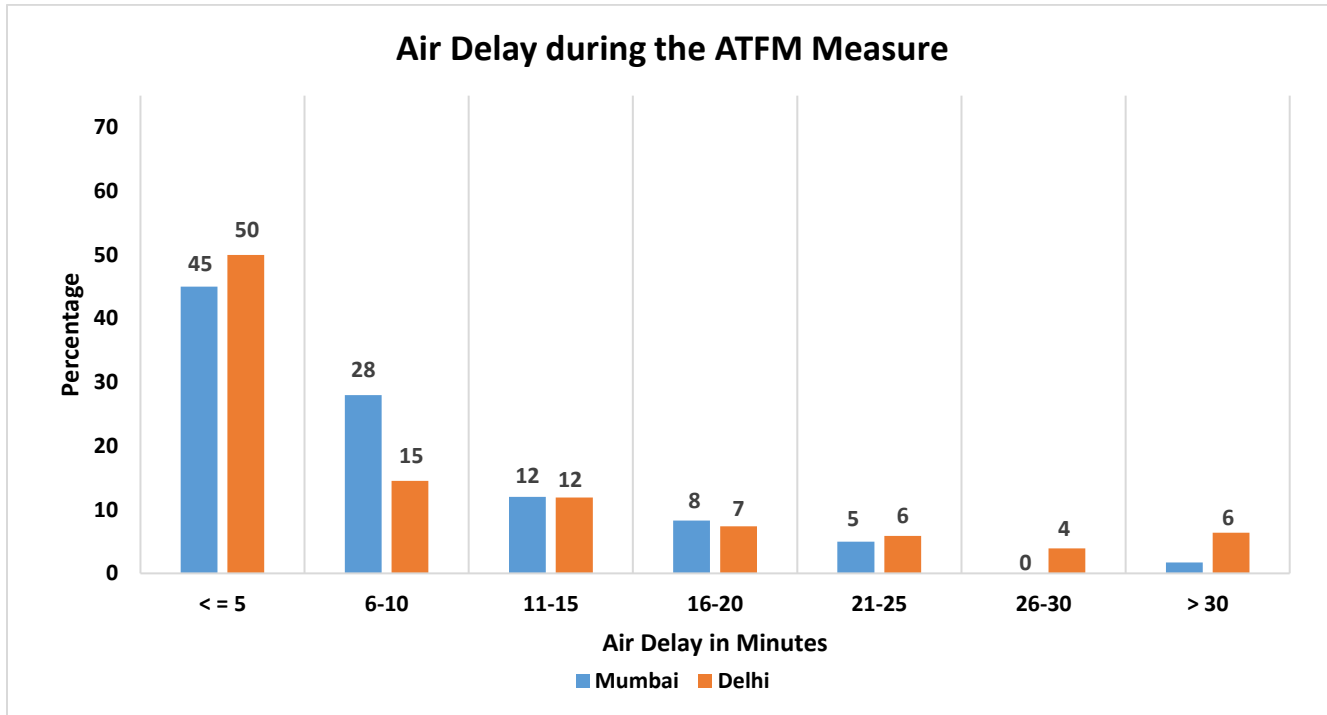
1. 31% of the CTOT Non-compliance was reported by concerned FMP to be because of Airline Operational reason.
2. 29% of the CTOT Non-compliance was reported by concerned FMPs due to late receiving of CTOTs and by the time the aircraft had initiated pushed back or startup. Few of the ATFM measures were initiated at short notice resulting in delay in dissemination of CTOTs.
3. 11% 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 as well as Mumbai Airport was 5.6 minutes.**

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



**Figure 15: Air Delay distribution during the CDM period**

### Inference

1. 73% of domestic arriving flights to Mumbai had an Air delay of equal to or less than 10 minutes during the CDM period.
2. 65% of domestic arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period.



## VIII. 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)= 8984 mins

Total Air Delay (with no ATFM measures) = 17894 mins

Reduction in Air delay due to ATFM measures= (17894-8984) = **8910 mins**

#### **Fuel Saving Calculation:**

Total Fuel saved during the ATFM Measure: **4,62,783.81 Kg**

**Total reduction in CO<sub>2</sub> emission : 3.16(KgCO<sub>2</sub>/kg fuel)\* 4,62,783.81 Kg = 1,462,396.84Kg**

*\*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 CO<sub>2</sub> produced by burning a tonne of aviation fuel.*



## D. Glossary

<b>ATFM Parameters</b>	<b>Definition</b>
<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
<i>Air delay statistics</i>	<p>Air delay defined as difference between AET &amp; 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). <b>Therefore, Air delay = AET-EET</b></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>