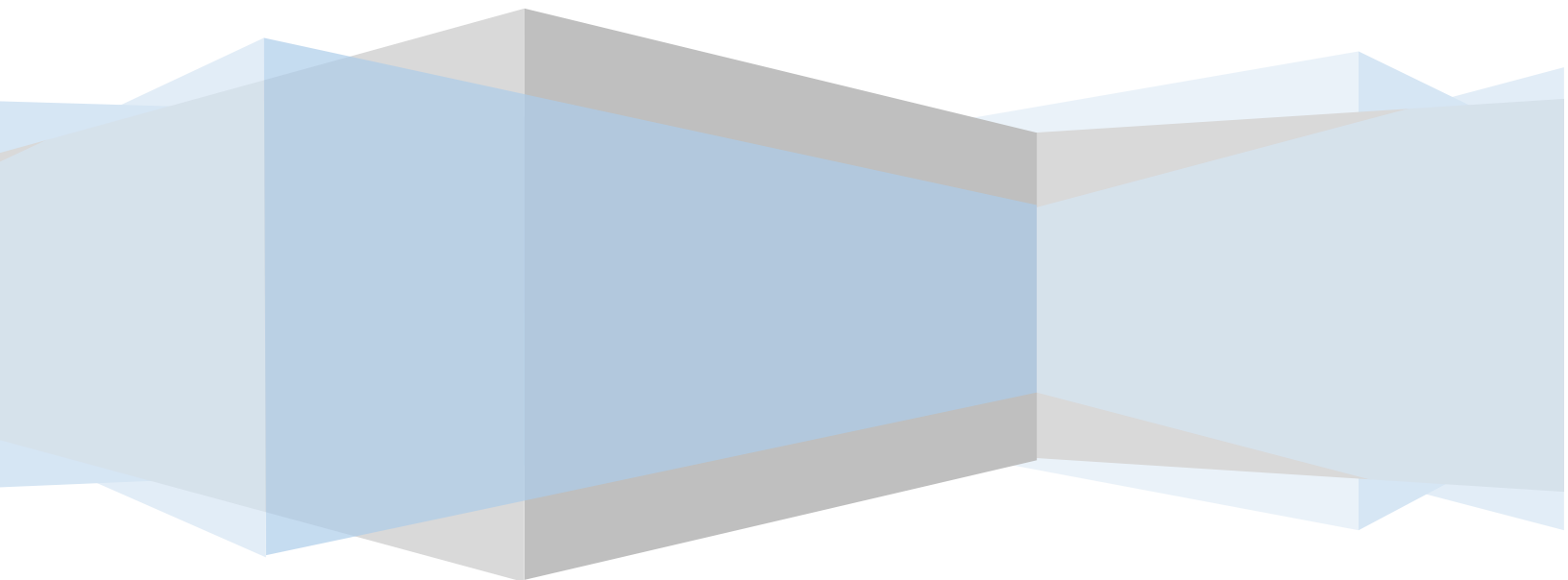


# POST OPERATIONS ANALYSIS REPORT

January, 2023

CENTRAL COMMAND CENTER, C-ATFM, DELHI







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## A. Executive Summary

Domestic air traffic has recorded a growth of 15.7 % whereas the international air traffic declined by 30.6 % in the month of January'23 as compared to December'22.

On average, the Indian Airports in the ATFCM area saw 4909 IFR flights per day in the month of January 2023. The peak day was on 27<sup>th</sup> January 2023 (5153 IFR flights). Friday's were the busiest days throughout this month with an average of 5033 domestic IFR flights per day.

Total Fourteen (14) ATFM measures were applied this month during periods of congestion at Delhi and Mumbai Airport.

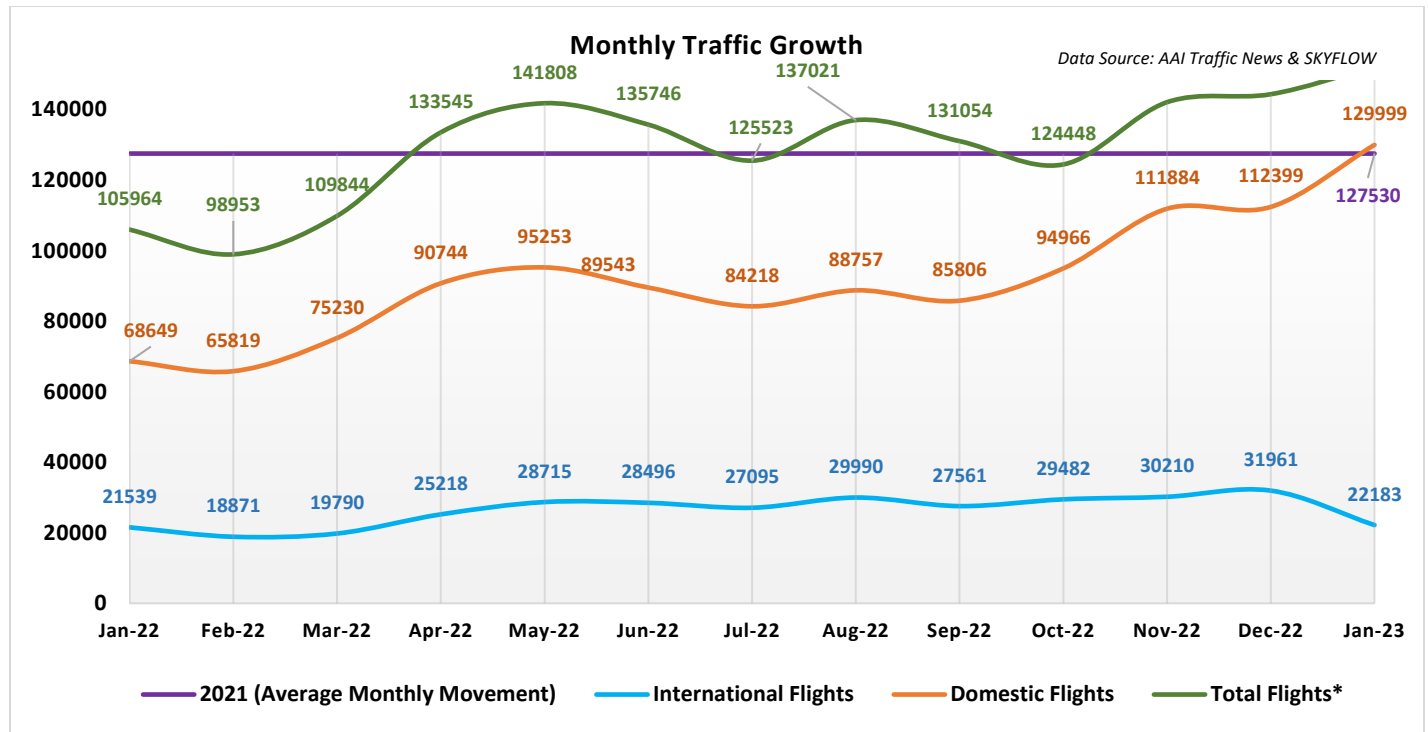


Figure 1: Monthly Traffic Growth

\*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 (Jan'2022 to Jan'2023). Domestic traffic surpassed the average monthly movement recorded for year 2021 in Jan'23.



## B. Traffic Analysis

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

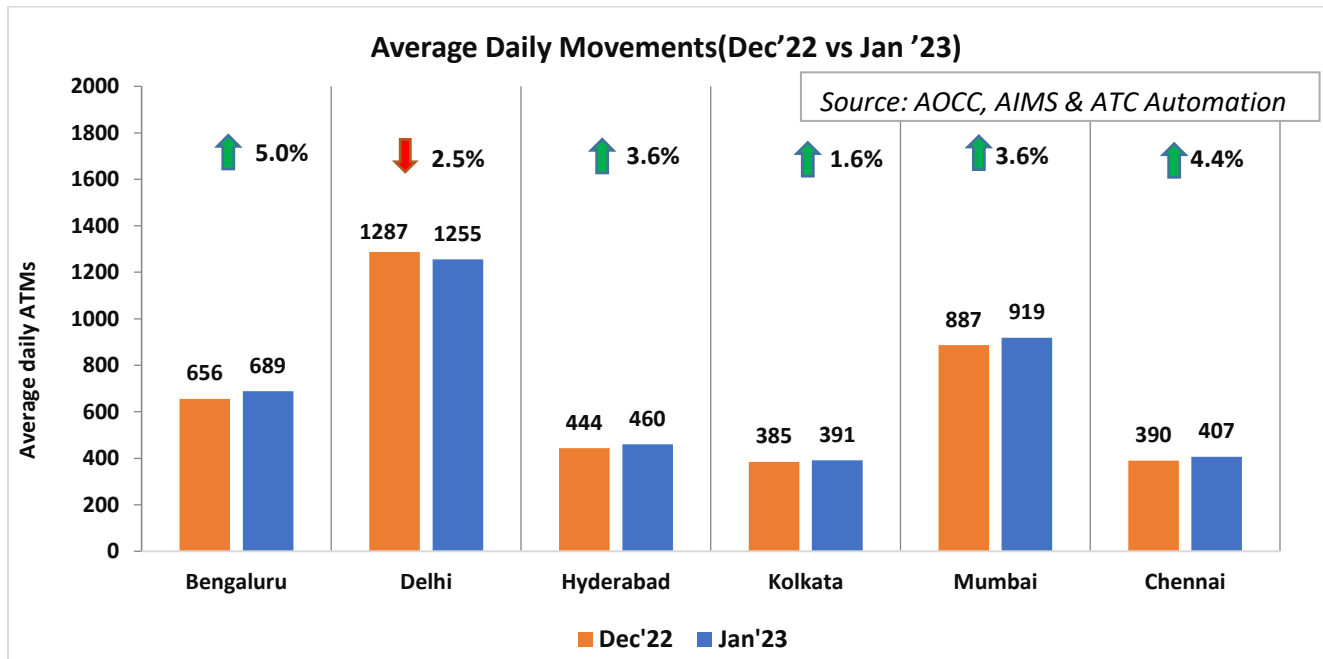


Figure 2: Average Daily Movements(Dec'22 vs Jan'23)

The above chart depicts the percentage change in average daily ATMs at six major Airports in Jan'23 compared to the previous month (Dec'22).

Airports\Year	Avg. Daily ATMs (YoY) for six major airports			
	Jan'20	Jan'21	Jan'22	Jan'23
Bengaluru	681	493	394	689
Delhi	1363	921	921	1255
Hyderabad	546	364	327	460
Kolkata	499	315	286	391
Mumbai	899	558	569	919
Chennai	506	301	278	390



Major Airports - Bengaluru ,Delhi, Hyderabad, Kolkata, Mumbai and Chennai Airport recorded average daily movements 101%,92%,84%,78%,102% and 77% respectively of that January 2020 levels(considered here as Pre-Covid level).

Air Traffic Movement for each day in Jan'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.

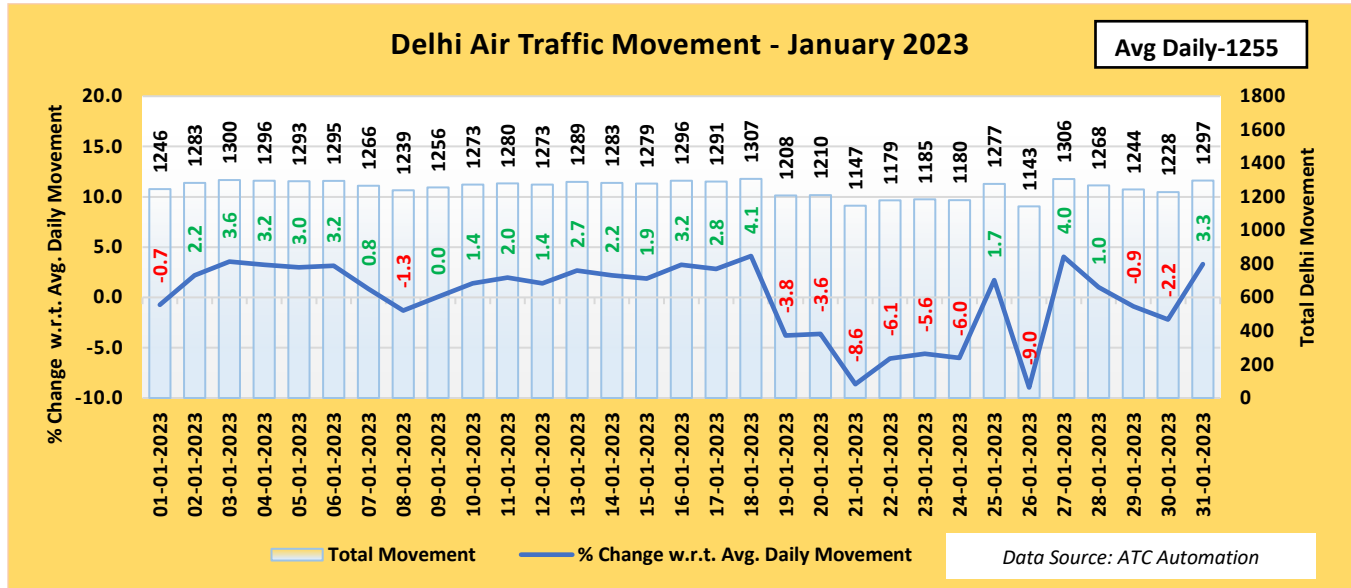


Figure 3: Air Traffic Movement for Delhi –January 2023

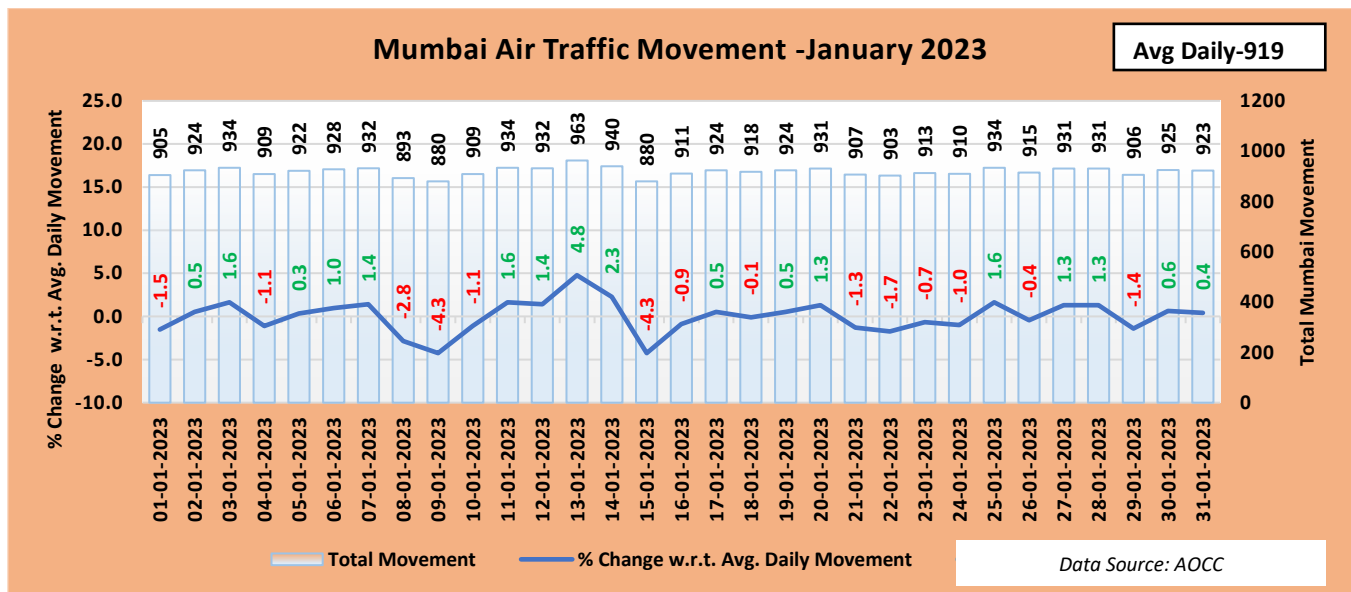


Figure 4: Air Traffic Movement for Mumbai - January 2023

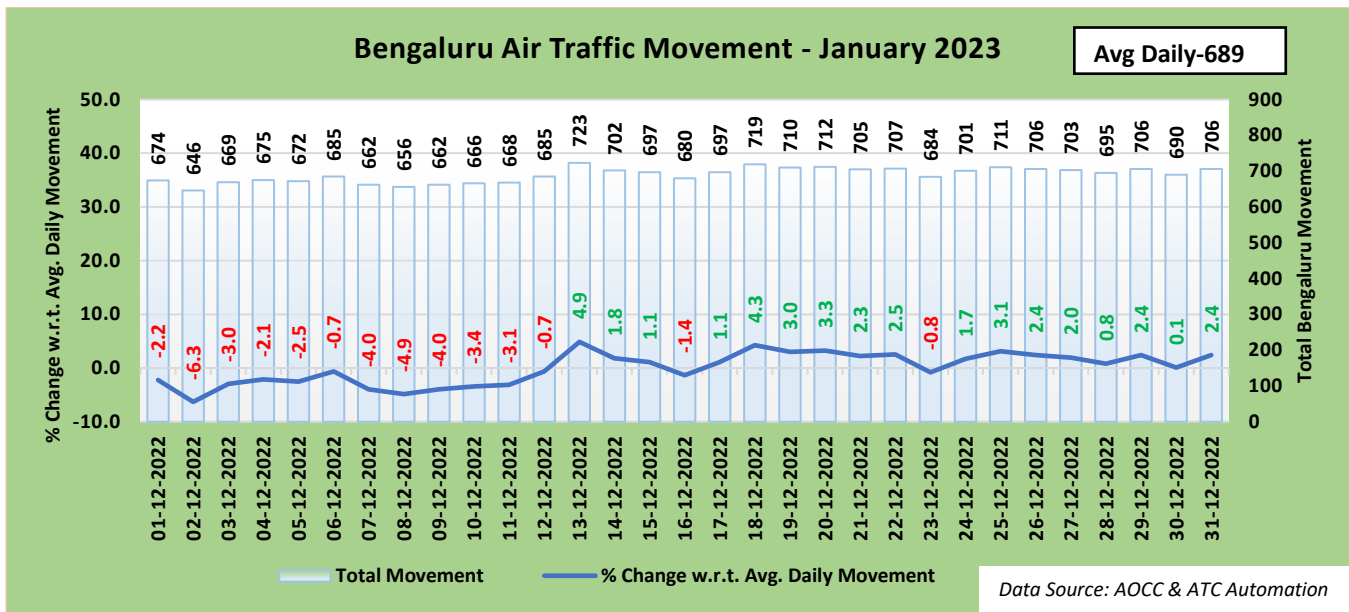


Figure 5: Air Traffic Movement for Bengaluru – January 2023

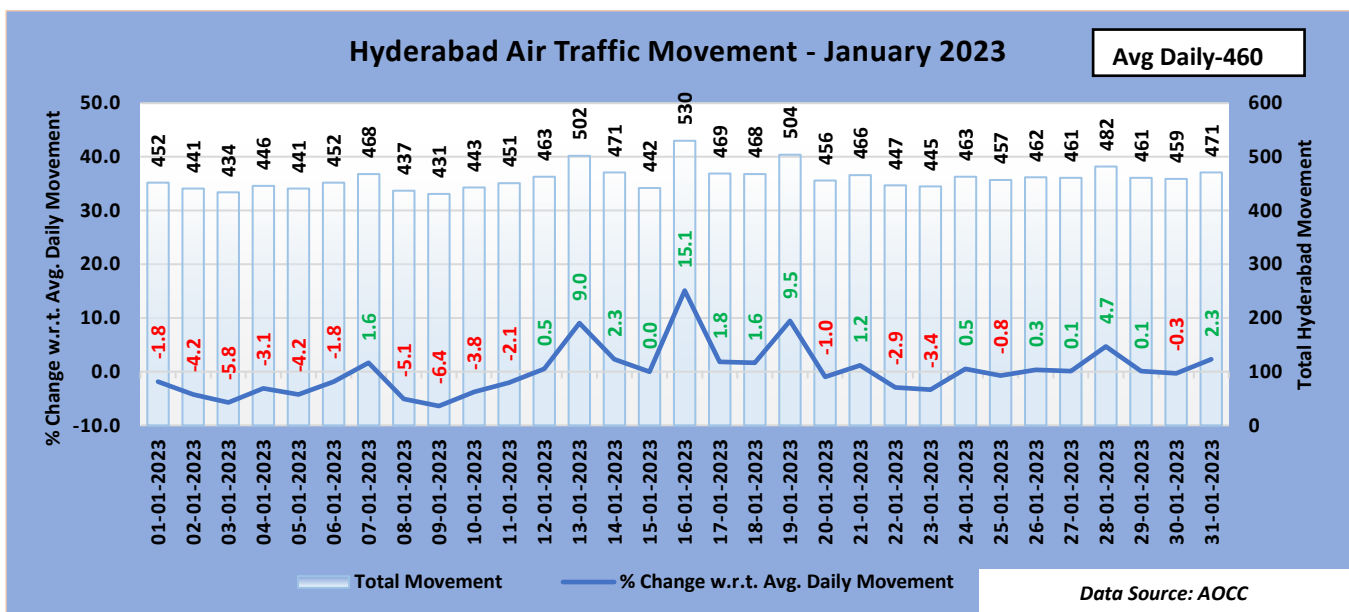


Figure 6: Air Traffic Movement for Hyderabad - January 2023

It is evident from the above charts that on month end(31st January 2023) the ATMs at Delhi ,Mumbai, Bengaluru and Hyderabad saw an increase of 3.3%, 0.4%, 2.4% and 2.3% respectively as compared to the average daily movement for the month of January'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 January 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.

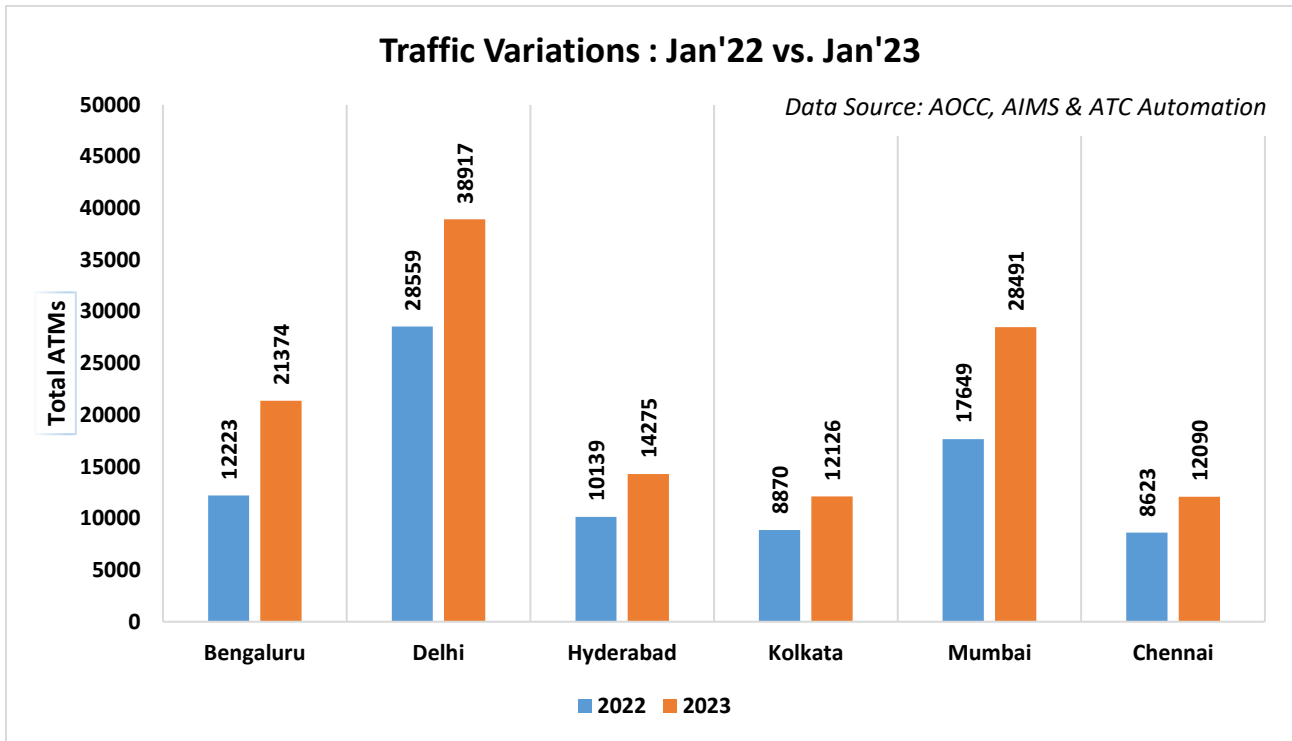


Figure 7: Traffic Variation (YoY)



### III. Flight Operations – Airlinewise

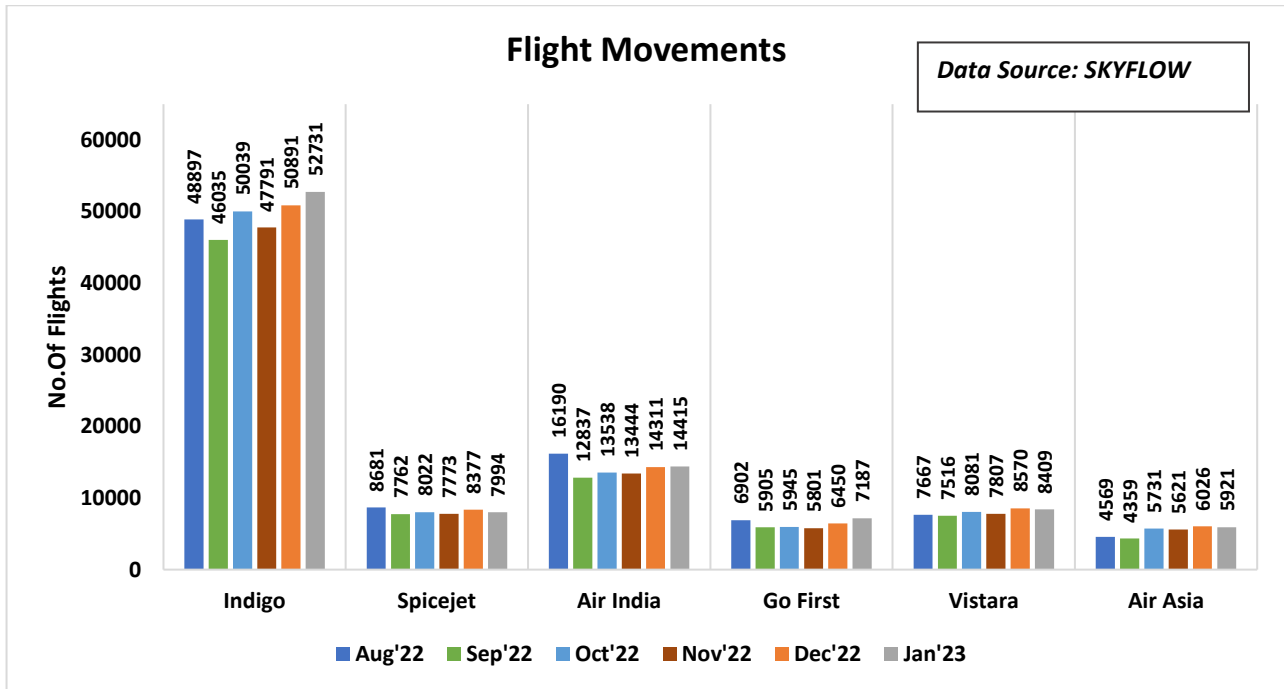


Figure 8: Flight Movements –Airlinewise

**Inference:**

1. Indigo, Air India and Go first Airlines have recorded higher Flight movements in Jan'23 as compared to Dec'22.
2. Spicejet, Vistara and Air Asia Airlines have recorded lesser flights in Jan'23 as compared to Dec'22.



## C. ATFM Post Operations – CDM Analysis

### I. Introduction

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

**Back Ground** During the above mentioned period, **seven (07)** ATFM measures were applied for **Delhi Airport** and **seven (07)** ATFM measures were applied for **Mumbai Airport** due to the following reasons as illustrated in the bar chart below:–

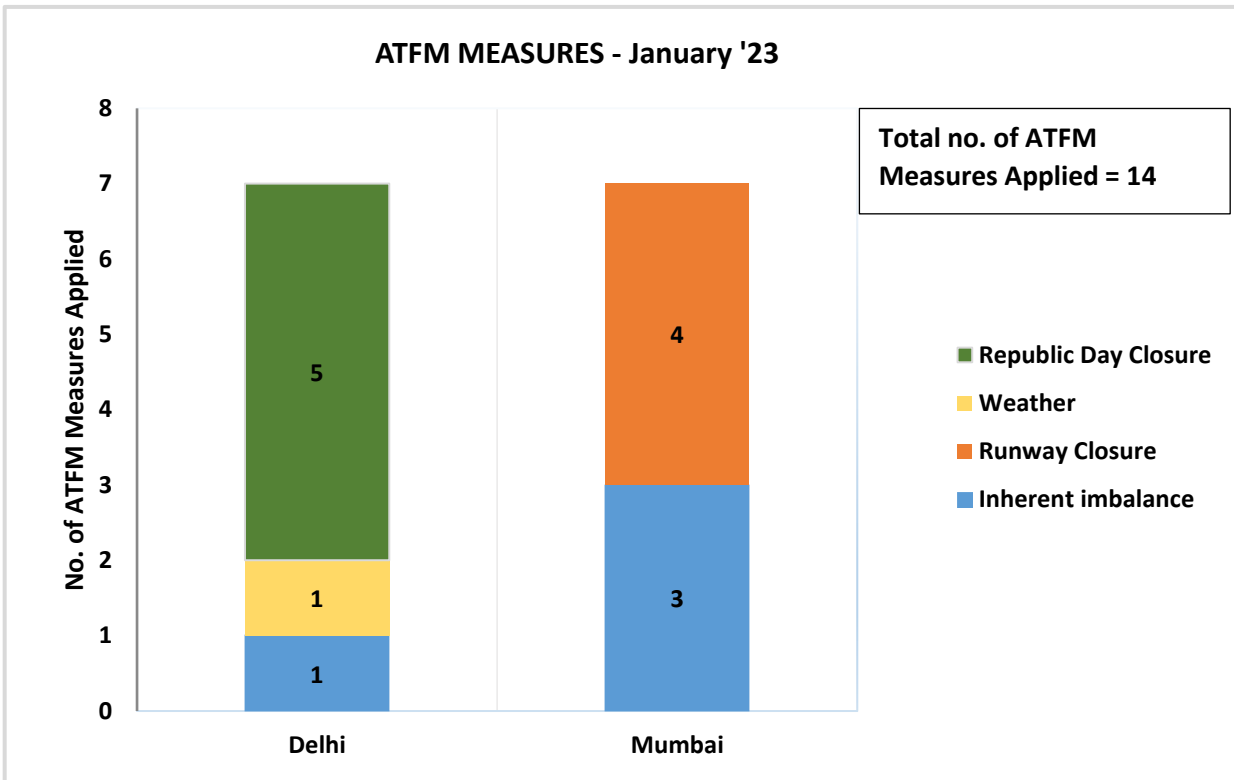


Figure 9: ATFM Measures –January'23



## II. ATFM Measures Overview

Constrained Airport	Delhi Airport	Mumbai Airport
Number of ATFM measures applied	7	7
Average ATFM Ground delay(in min) due to measures*	24.4	12
Maximum ATFM Ground delay(in min) due to measures	73	43
% Compliance	79	78

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

Total Arrivals	825
Total International Arrivals(exempted)	175
Total affected flights in scenario (Domestic Arrivals)	650
Total Domestic Arrivals with zero ATFM delay	78
Total Domestic Arrivals with ATFM delay	572

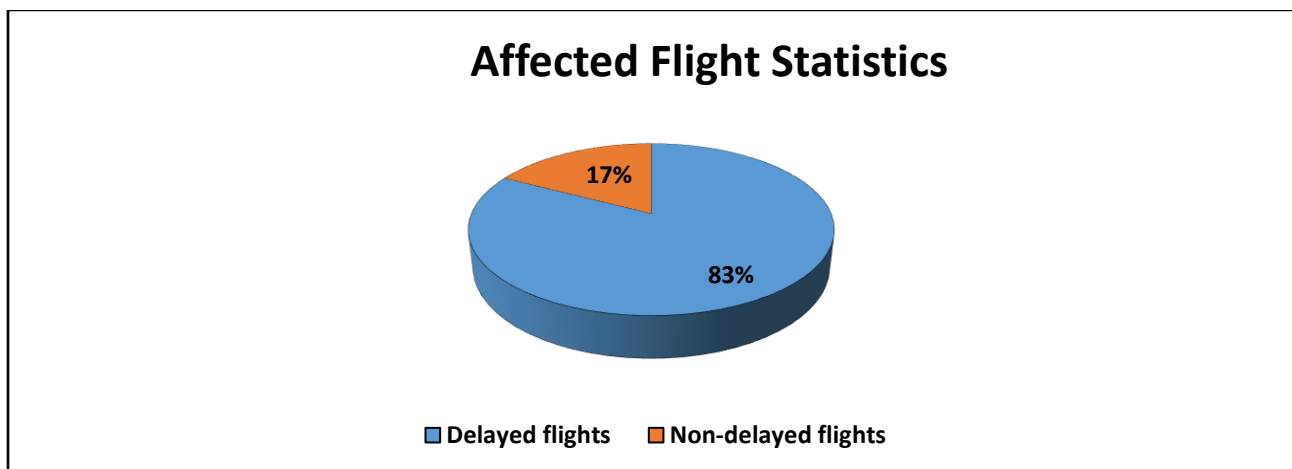


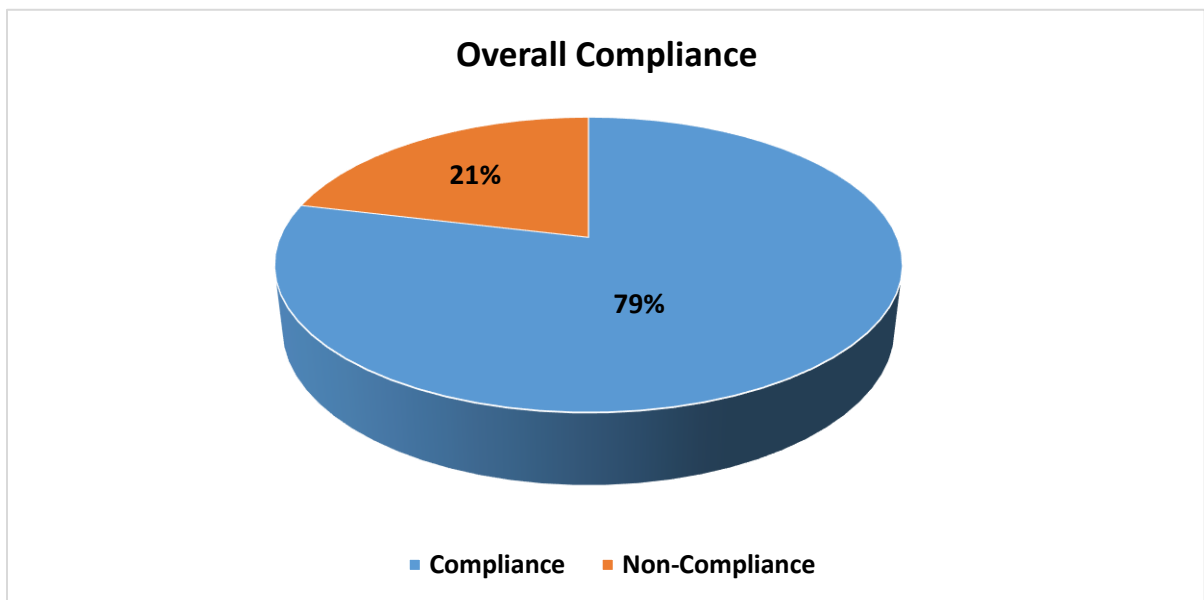
Figure 10: Affected Flight Statistics –Jan'23



### III. Overall Compliance

<b>Total arrivals</b>	825
<b>Domestic arrivals</b>	650
<b>Flights with complete data (ATOT)</b>	626
<b>Flights with incomplete data</b>	10
<b>Flights Not Operated</b>	14
<b>Compliant*</b>	493
<b>Non-Compliant</b>	133

\*Total No. of Revised CTOTs issued = 140 (Compliance calculation for flights which were issued revised CTOT is w.r.t. new CTOT issued)



**Figure 11: Overall Compliance – Jan’23**

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

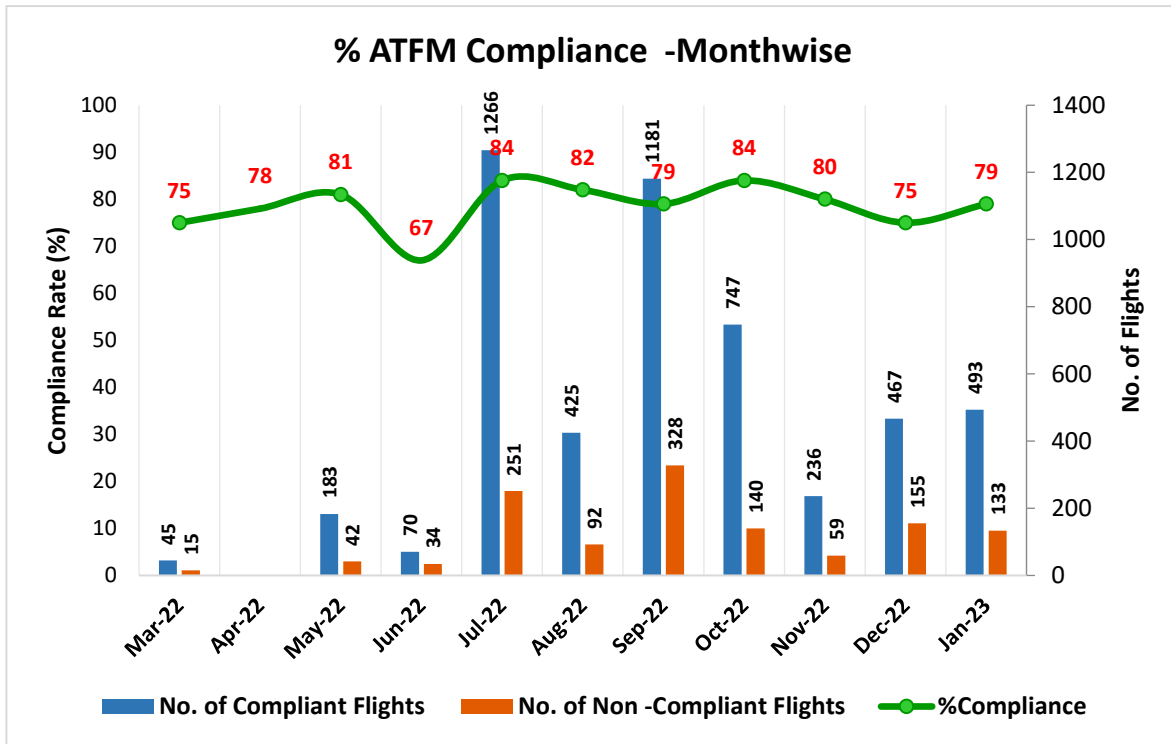


Figure 12: Compliance(Monthwise)

### Inference

1. Out of the total arrivals captured(825 flights) during the CDM scenario for the constrained Airports, 82% of flights i.e. domestic arrivals(650 flights) were candidates for ground delay(participating).
2. Out of these Domestic Arrivals, 88% (572 flights )are assigned ATFM ground delay.
3. Out of the total arrivals captured(825 flights) to the constrained Airport during the ATFM scenario, only 69% of flights(572 flights) were assigned ATFM Ground Delay.



## IV. CTOT Compliance rate – Airportwise

<b>MUMBAI FIR (83%)*</b>	<b>Compliant</b>	<b>Non Compliant</b>	<b>% Compliant</b>
Ahmedabad	18	4	82%
Mumbai	31	3	91%
Bhuj	1	0	100%
Bhopal	4	0	100%
Diu	2	2	50%
Indore	9	2	82%
Jamnagar	4	2	67%
Kandla	1	0	100%
Keshod	1	0	100%
Nagpur	5	2	71%
Nasik	4	1	80%
Pune	5	2	71%
Rajkot	12	0	100%
Surat	2	1	67%
Udaipur	12	3	80%
<b>KOLKATA FIR (88%)*</b>	<b>Compliant</b>	<b>Non Compliant</b>	<b>% Compliant</b>
Prayagraj	2	0	100%
Agartala	5	0	100%
Siliguri	19	3	86%
Varanasi	17	1	94%
Bhubaneswar	3	1	75%
Kolkata	28	2	93%
Chakeri	3	0	100%
Durgapur	3	0	100%
Darbhanga	5	3	63%
Gorakhpur	2	1	67%
Guwahati	14	2	88%
Imphal	1	0	100%
Aizawl	0	1	0%
Dibrugarh	5	0	100%
Patna	10	1	91%
Ranchi	6	2	75%
Raipur	3	1	75%



DELHI FIR (73%)*	Compliant	Non Compliant	% Compliant
Ambala	0	1	0%
Amritsar	5	1	83%
Bikaner	3	1	75%
Bareilly	1	0	100%
Chandigarh	12	3	80%
Dehradun	2	2	50%
Delhi	24	6	80%
Kangra	5	1	83%
Gwalior	1	0	100%
Jodhpur	11	4	73%
Jaipur	10	4	71%
Jaisalmer	3	1	75%
Jammu	7	3	70%
Ludhiana	1	0	100%
Leh	4	3	57%
Lucknow	4	1	80%
Pathankot	0	1	0%
Shimla	1	0	100%
Sarsawa Air Force Station	0	1	0%
Srinagar	20	10	67%
CHENNAI FIR (75%)*	Compliant	Non Compliant	% Compliant
Hal Bangalore	1	1	50%
Bengaluru	31	11	74%
Coimbatore	6	0	100%
Kochi	12	1	92%
MOPA Goa	7	4	64%
Goa	14	16	47%
Hubli	4	1	80%
Hyderabad	23	2	92%
Begumpet Hyderabad	1	0	100%
Kannur	4	0	100%
Madurai	2	1	67%
Mangalore	4	2	67%
Chennai	23	4	85%
Port Blair	2	3	40%





Rajahmundry	1	0	100%
Sindhudurg	1	1	50%
Tirupati	1	0	100%
Thiruvananthapuram	5	0	100%
Visakhapatnam	0	1	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(79%) for the month are highlighted in red.

### V. CTOT Compliance rate – Airline wise

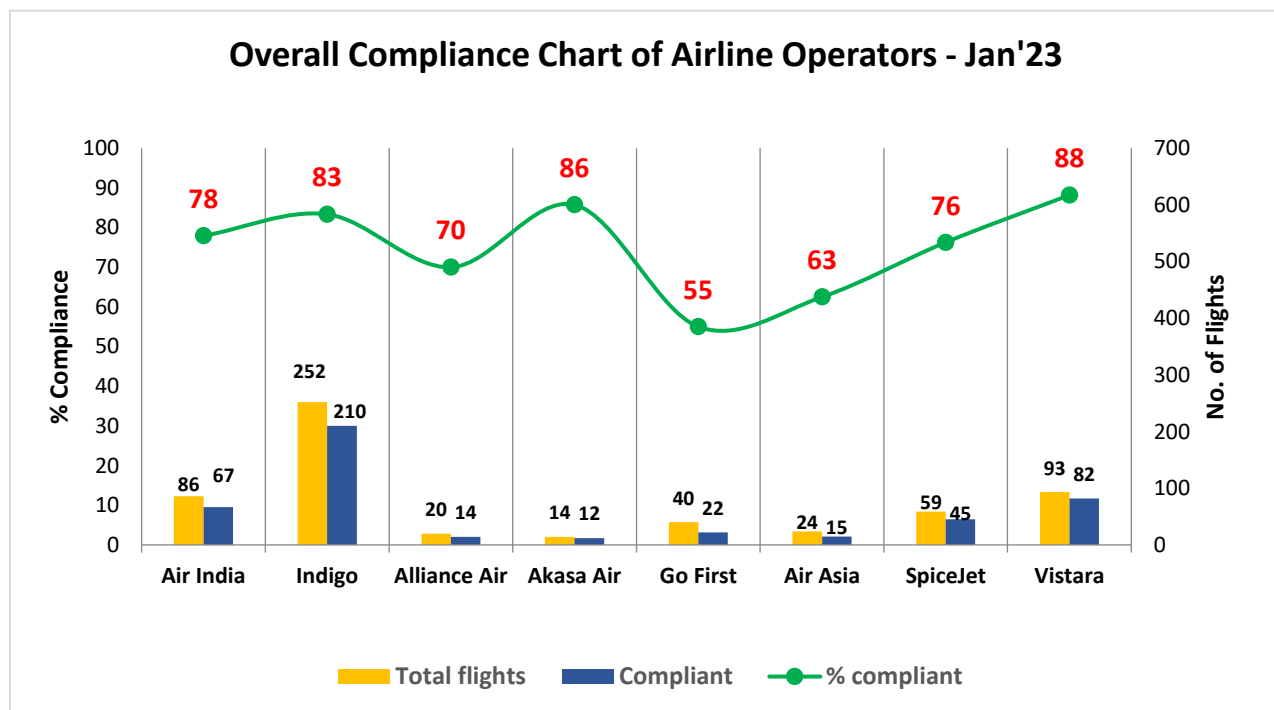


Figure 13: Airline wise Compliance –Jan’23

### Inference

1. Out of the total domestic arrivals with complete data in the CDM scenario, 79% arrivals are compliant.

2. Kolkata region has the highest compliance rate of 88% whereas Delhi region has the lowest compliance rate of 73%.

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

## VI. Reason For Non Compliance

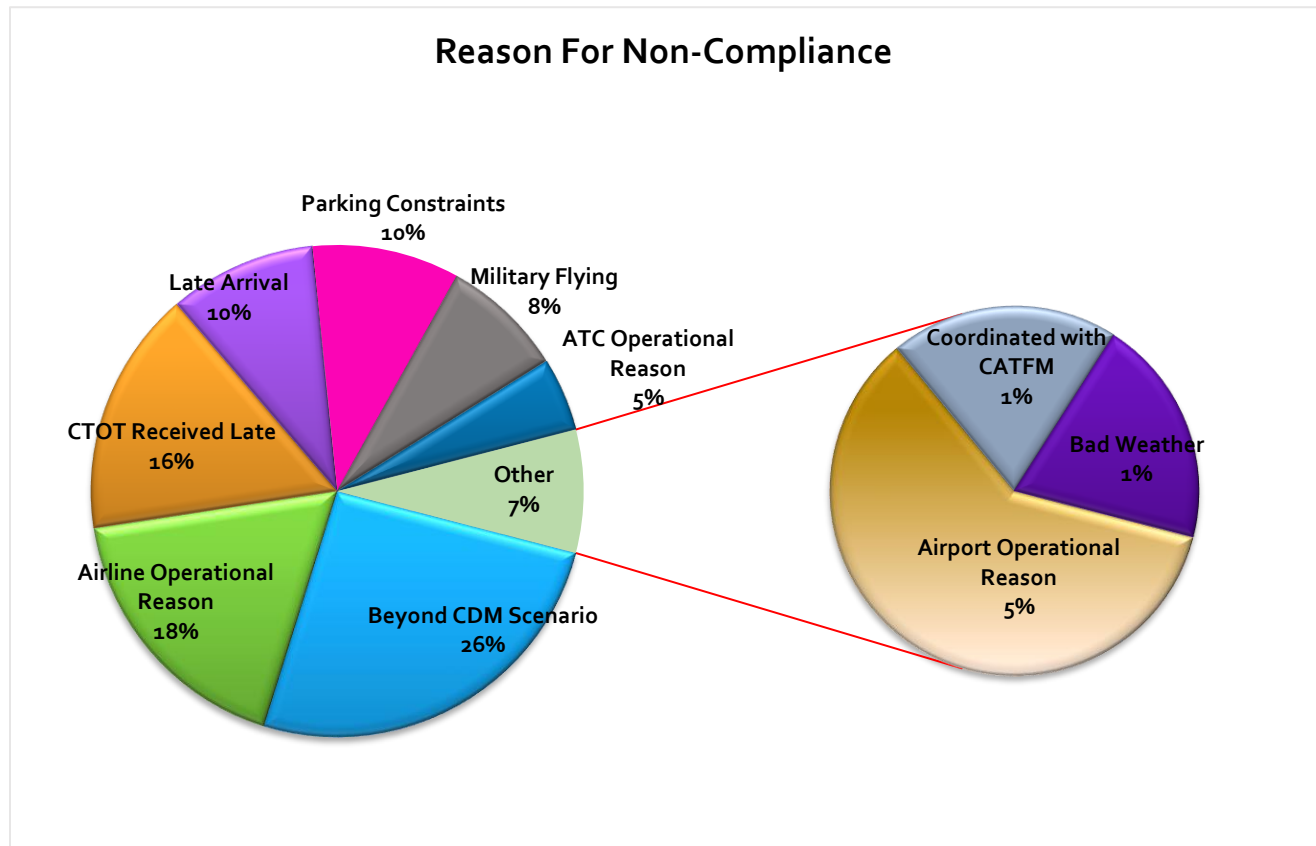


Figure 14: Reason for Non-Compliance as provided by FMPs

### Inference:

- 26% of the CTOT Non-compliance was reported because of flights being delayed and operating beyond the CDM scenario. Such flights revise their EOBT very close to the time of operation resulting in wastage of unused slots.
- 18% of the CTOT Non-compliance was reported by concerned FMP to be because of Airline Operational reason.
- 16% 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.



## 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 minutes.

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

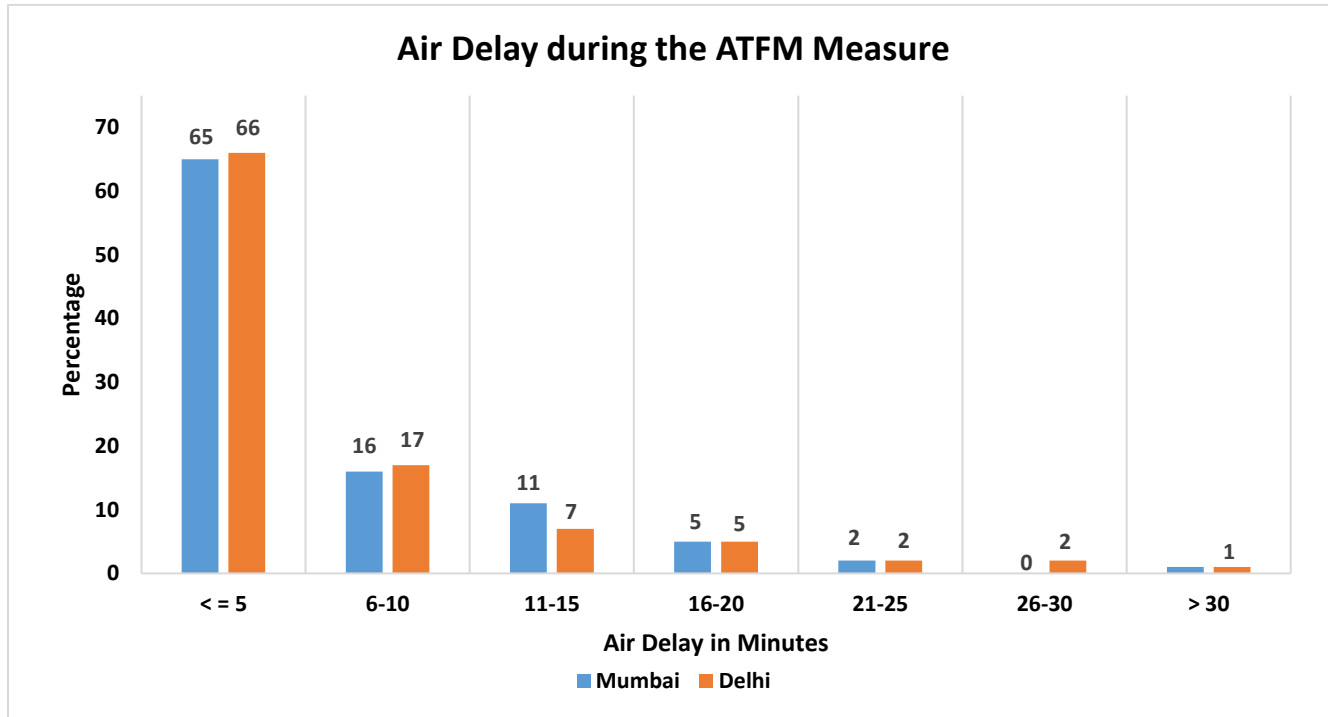


Figure 15: Air Delay distribution during the CDM period

### Inference

1. 81% of domestic arriving flights to Mumbai had an Air delay of equal to or less than 10 minutes during the CDM period.
2. 83% 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)= 1804 mins

Total Air Delay (with no ATFM measures) = 13694 mins

Reduction in Air delay due to ATFM measures= (13694-1804) = **11890 mins**

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

Total Fuel saved during the ATFM Measure: **6,43,222.39 Kg**

**Total reduction in CO<sub>2</sub> emission : 3.16(KgCO<sub>2</sub>/kg fuel)\* 6,43,222.39 Kg = 20,32,582.75 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 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>



## Annexure-I

# CASE STUDY

## Republic Day Airspace Closure(2023)

### A. Introduction:

Due to the Republic Day celebrations, Delhi Airport/Airspace was closed as specified vide NOTAM no. A0066/23, A0075/23 & A0076/23. Restrictions were also imposed on domestic non-scheduled movements vide A0108/23

#### (A0075/23 NOTAMN

Q) VIDF/QFAXX/IV/BO/A/000/999/

A) VIDP B) 2301190450 C) 2301260715

D) JAN 19-26 0450-0715 EXC 25

E) NO LDG AND TKOF PERMITTED AT IGI AP, NEW DELHI (VIDP) DUE REPUBLIC DAY CELEBRATIONS.)

#### (A0076/23 NOTAMN

Q) VIDF/QRACA/IV/NBO/W/000/200/

A) VIDF B) 2301190500 C) 2301260715

D) JAN 19-26 0500-0715 EXC 25

E) AIRSPACE WI A RADIUS OF 50NM AROUND DELHI VOR (DPN), EXCLUDING AREAS OF 10NM RADIUS AROUND SIKANDRABAD VOR (SSB) AND 10NM AROUND SAKRAS VOR (SKA), NOT AVBL DUE REPUBLIC DAY CELEBRATIONS.

F) GND G) FL200)

#### (A0108/23 NOTAMN

Q) VIDF/QFAXX/IV/BO/A/000/999/

A) VIDP B) 2301190430 C) 2301240745

D) DLY 0430-0745

E) IN VIEW OF AIRSPACE CLOSURE AND EXP TFC CONGESTION,DOM NON-SKED FLT NOT PERMITTED TO OPR AT IGI AP .)



**(A0066/23 NOTAMN**

Q) VIDF/QFAXX/IV/NBO/A/000/999/

A) VIDF B) 2301260300 C) 2301291330

D) 26 0300-0730 0930-1230,

29 0930-1330

E) 1. IN CONNECTION WITH REPUBLIC DAY CELEBRATIONS, NO FLT PERMITTED TO TKOF/LAND, AT INDIRA GANDHI INTERNATIONAL AP (VIDP), NEW DELHI AND SUBSIDIARY AIRPORTS WI A RADIUS OF 300KM AROUND DELHI (WI DELHI FIR) , EXC FLW FLT:

I. SKED FLT BY THE SKED FLT OPERATORS.

II, IAF, BSF AND ARC FLT.

III. ARMY AVIATION HELICOPTER FLT UNDERTAKING AIRBORNE QRT MISSIONS AND CASUALTY/ IMMEDIATE MEDICAL EVACUATION.

IV. STATE OWNED ACFT/ HELICOPTER FLYING THE GOVERNOR OR CHIEF MINISTER OF A STATE.

2. SKED FLT BY SKED OPERATORS ON ATS RTE PERMITTED

A) TO OVERFLY A ZONE OF 300KM RADIUS AROUND IGI AIRPORT (DELHI) ABOVE F290.

B) TO TKOF OR LAND FM/AT A SUBSIDIARY AIRFIELD LOCATED BEYOND 300KM FM DELHI PROVIDED WHILE CLIMBING SHALL ATTAIN F290 BY 200KM TO DELHI AND WHILE DESCENDING, SHALL COMMENCE DESCEND FM F290 AT A DIST OF 200KM OR MORE FM DELHI.

3. SAFDARJUNG AP (VIDD) SHALL REMAIN CLSD DRG THE ABV MENTIONED DATES AND TIMINGS EXCEPT FOR IAF HELICOPTERS, WHICH MAY BE DEPLOYED ON EMERGENCY DUTY OR VVIP DUTY, FLY PAST ACTIVITIES AND BSF/IAF HELICOPTERS UTILISED BY THE NSG.

4. ROHINI HELIPORT (284507N0770331E) SHALL REMAIN CLSD DRG ABOVE MENTIONED DATES AND TIMINGS.

F) GND G) UNL)





## B. Executive Summary

A virtual meeting was conducted on 17<sup>th</sup> Jan'23 with all stakeholders' including senior officers from Delhi ATC, DIAL, Airlines, NAMC, Indian Airforce and officer from IMD to discuss the modalities for the upcoming Delhi Airspace/Airport closure and review last year's Airspace closure.

Revised schedule approved by DIAL was promptly shared with ATFM team. Airlines also shared their fortnightly flight data incorporating the changes w.r.t. Airport closure, well in advance, to upload in SKYFLOW system.

A representative from Air India & Indigo Airlines was physically present in CCC for all days of the exercise. Representatives from Go First, Vistara and Air Asia were only available on few days of the exercise. Their physical presence facilitated timely and effective coordination with their Flight dispatch and operations regarding revised flight intent and unused slots.

All ATS in-charges/FMPs were proactively informed regarding the NOTAM in respect of the Republic Day Airspace closure at Delhi and advised to ensure that FMP position was manned by SKYFLOW trained staff to facilitate CTOT extraction, dissemination and compliance.

Exercise was called off on 22<sup>nd</sup> and 24<sup>th</sup> Jan'22 by Indian Airforce.

## C. Challenges:

1. Technical glitch was faced in uploading the Flight intent in the SKYFLOW system and help of the vendor was sought.
2. PRI lines for communication were intermittent on the 1<sup>st</sup> Day of exercise.
3. Non-compliance of CTOT was observed from Chennai, Hyderabad (VOHS), Bengaluru, MOPA and Bagdogra on initial day of exercise.
4. CTOT dissemination to smaller Airports (under the Regional Connectivity Scheme) and a few Air force station still remains a challenge.

## D. Highlights:

1. Stakeholder's meeting prior to the closure helped in raising awareness about the applicable NOTAM and proposed ATFM measures.
2. Better coordination with Delhi ATC as per the agreed plan. Pre closure traffic was handled tactically by Delhi ATC as agreed in Stakeholders Meeting and hence no measure was applied.
3. Presence of Airline representatives from 2 major Airlines helped in communication flow.
4. Regulated flow of Air traffic to Delhi ATC post the reopening of Airspace ensured less airborne holdings except on 26<sup>th</sup> Jan'23 when holding was observed.
5. Weather prediction by IMD was accurate for most days of the exercise.

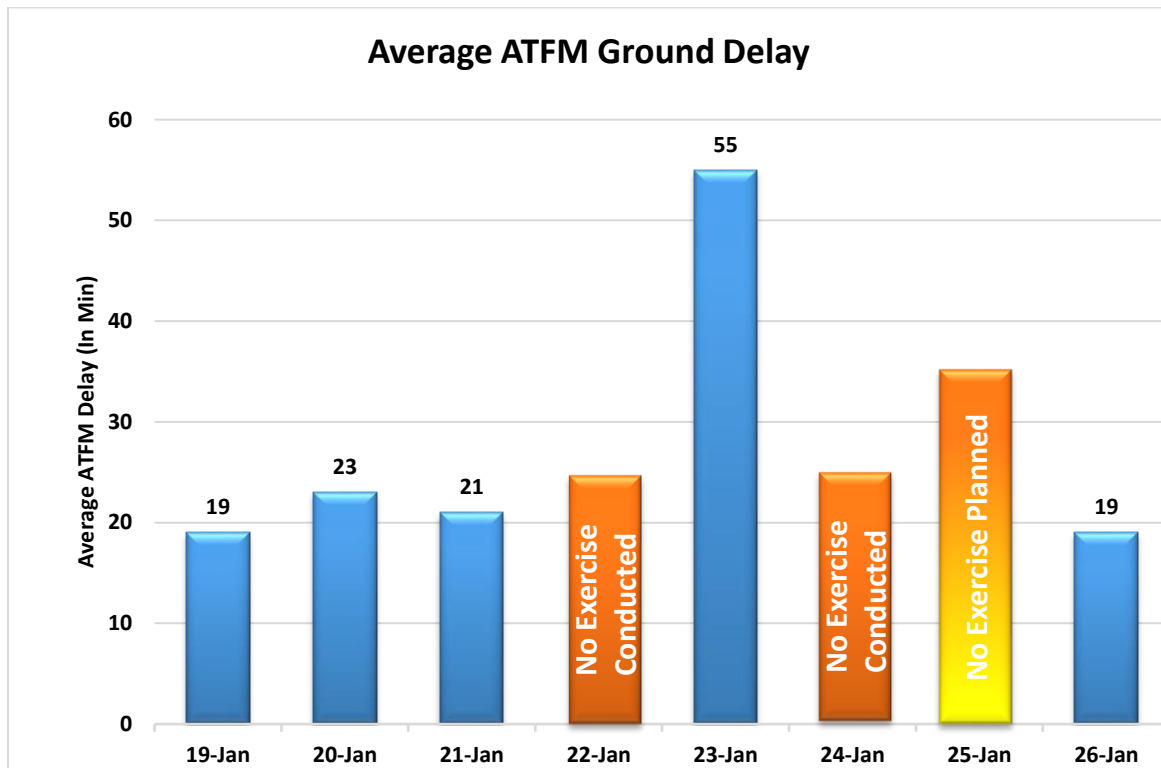


### E. Overview:

The data for the period during which ATFM measures were applied in Delhi on 19<sup>th</sup>, 20<sup>th</sup>, 21<sup>st</sup>, 23<sup>rd</sup> & 26<sup>th</sup> January 2023 was analyzed for following ATFM parameters.

*(Flights with complete data i.e. ATOT, ALDT etc. are only taken into consideration. ATOT was obtained from all concerned airports for verifying CTOT compliance.)*

#### I. Average ATFM Ground Delay

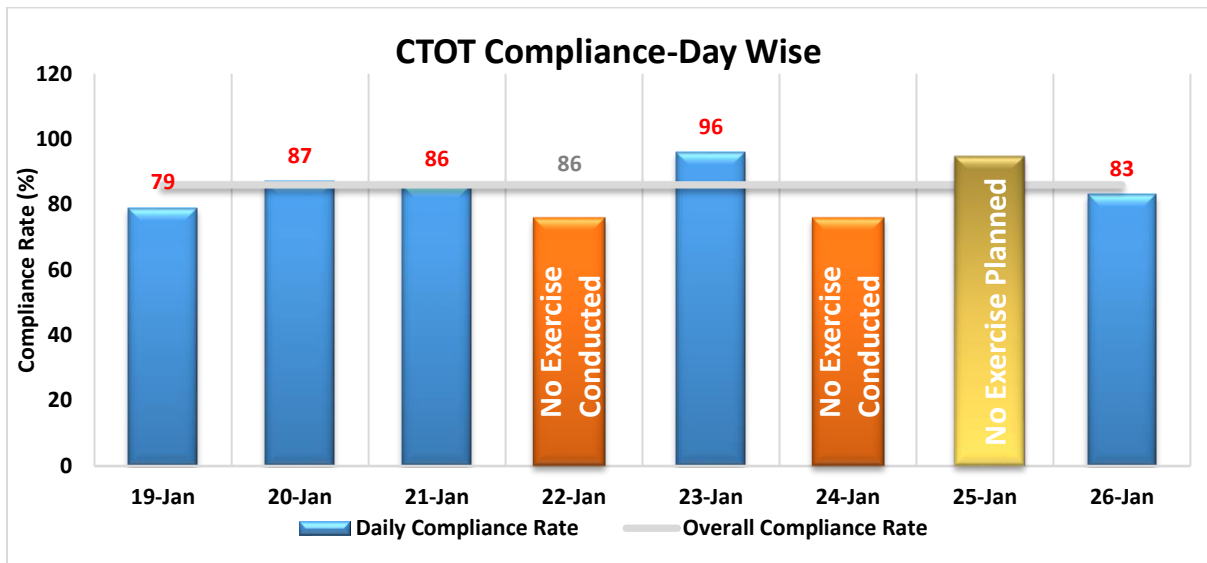


#### Inference

1. Average ATFM ground delay was large on 23<sup>rd</sup> Jan'23 as compared to other days due to less arrival acceptance rate (AAR) by ATC considering the weather and easterly mode of operations.



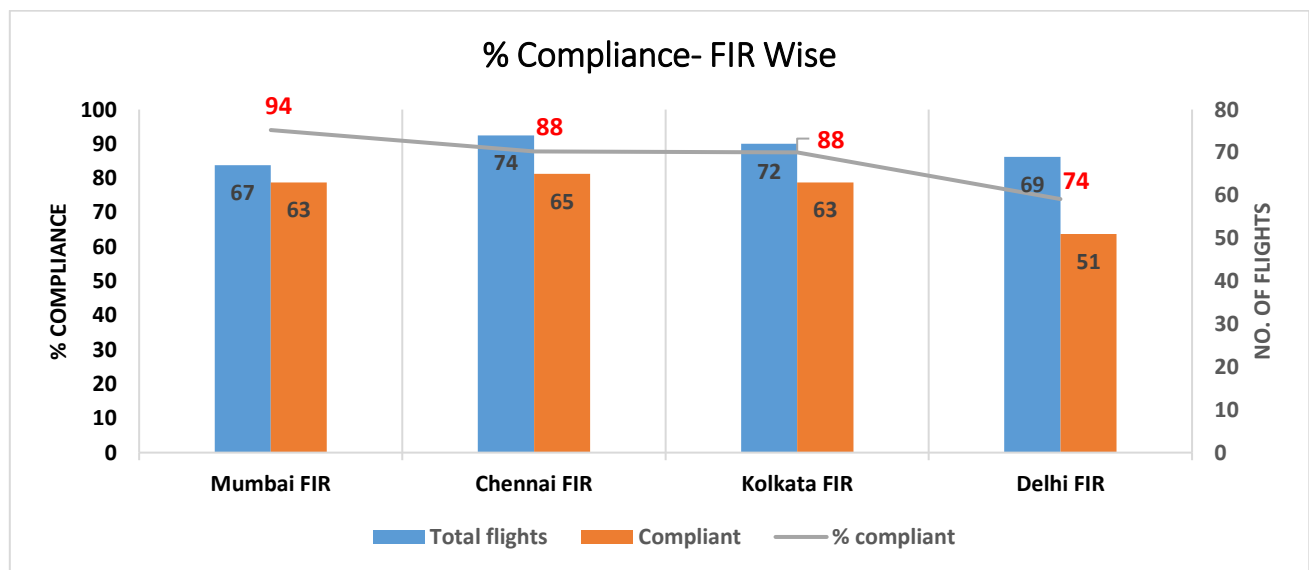
## II. CTOT Compliance – Day wise:



### Inference:

1. Percentage compliance was on the lower side on the initial day of the exercise which improved on the subsequent days of the closure.

## III. CTOT Compliance (FIR-wise)

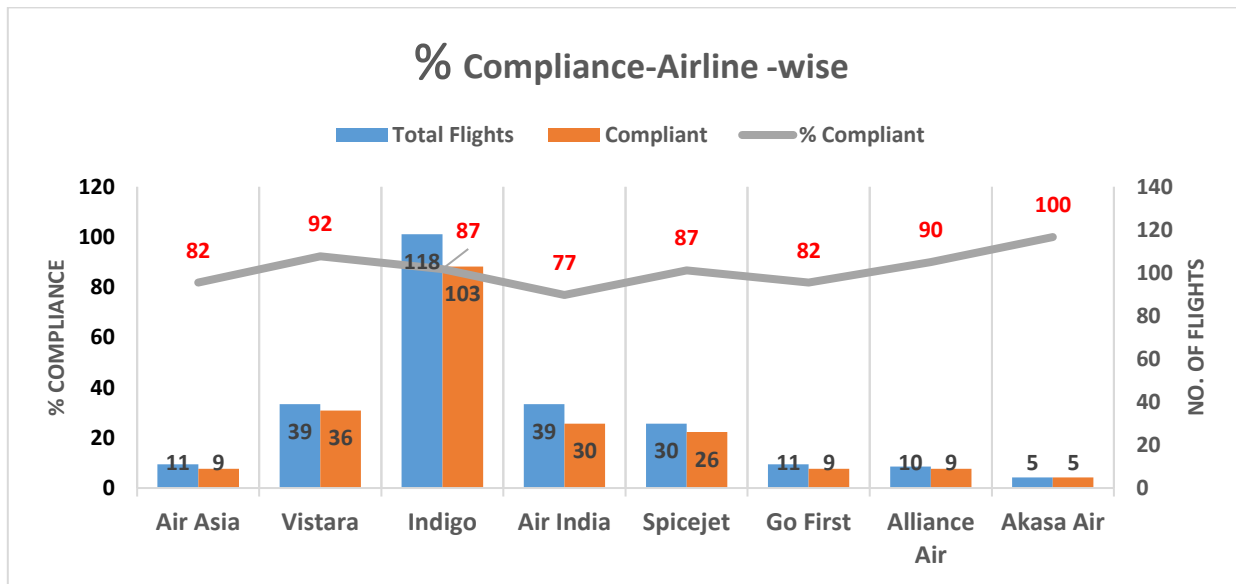


### Inference:

1. Mumbai FIR has the highest Compliance of 94% whereas Delhi FIR has the lowest of 74%.



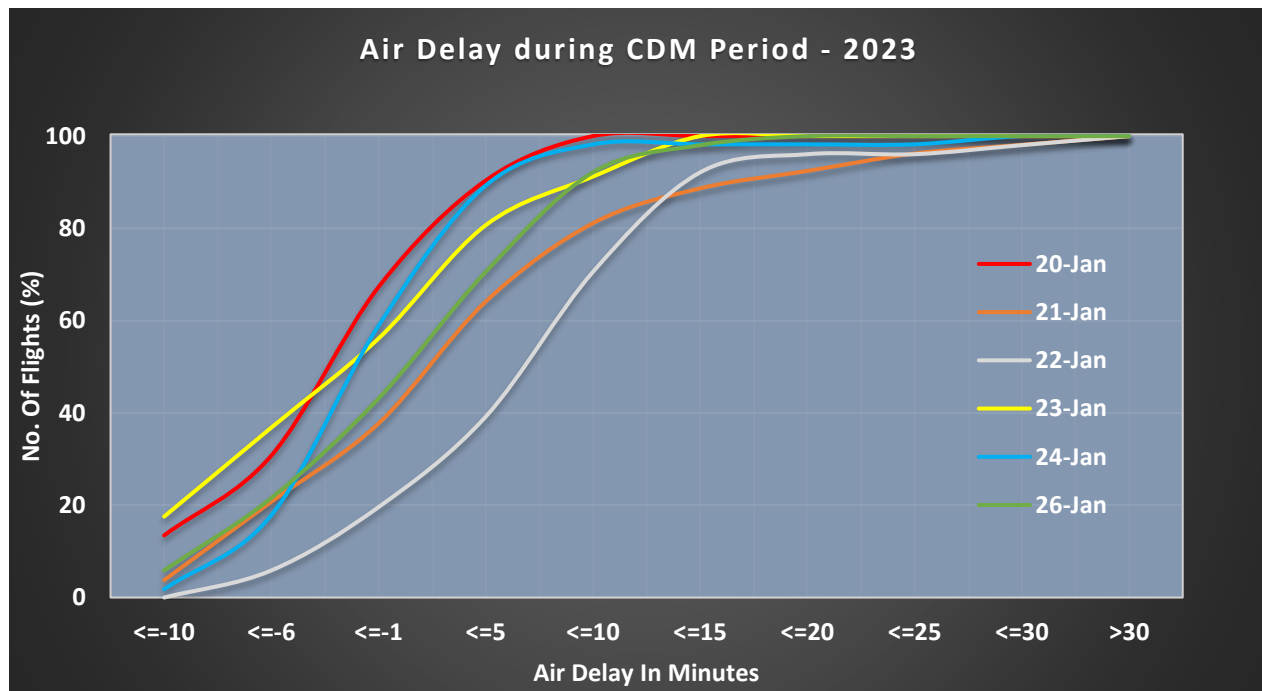
#### IV. CTOT Compliance (Airline-wise)



#### Inference

1. Akasa Air has the highest % compliance whereas Go First Airline has the lowest compliance of 39%. Majority of the Airlines have a compliance above 80%.

#### V. Cumulative Air Delay during the period when ATFM measures were inforce.



**Inference:**

1. 89% of arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period on 19th Jan'23.
2. 96% of arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period on 20th Jan'23.
3. 98% of arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period on 21st Jan'23.
4. 77% of arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period on 23rd Jan'23.
5. 75% of arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period on 26th Jan'23

**F. Fuel Saving due to ATFM Measures during the Republic Day closure:**

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

Total Air delay (with ATFM measures) = **176 min**

Total Air delay (with no ATFM measures) = **8743 min**

Total amount of Air delay reduced due to ATFM measures=  $8743-176=$  **8567 min**

**Fuel Saving Calculation:**

Total Fuel saved during the ATFM Measure: **484504.93 Kgs**

**Total reduction in CO<sub>2</sub> emission :  $3.16(\text{KgCO}_2/\text{kg fuel}) * 484504.93 \text{ Kgs} = 15,31,036 \text{ Kg}$**

*3.16 = constant representing the number of tonnes of CO<sub>2</sub> produced by burning a tonne of aviation fuel.*