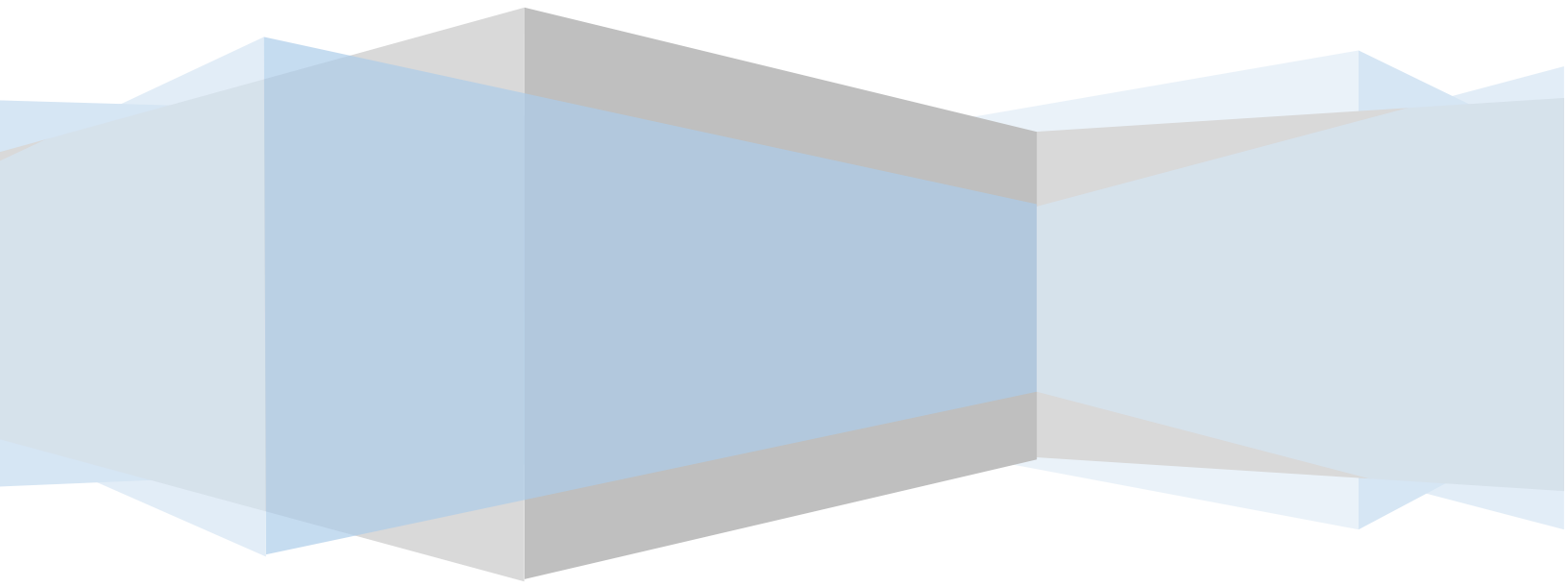
POST OPERATIONS ANALYSIS REPORT

December, 2023

CENTRAL COMMAND CENTER, C-ATFM, DELHI



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A. Executive Summary

Average Domestic air traffic has recorded an increase of 0.1 % whereas the average international air traffic has increased by 2.1% in the month of Dec'23 as compared to Nov'23.

On average, the Indian Airports in the ATFCM area saw 4941 IFR flights per day in the month of December 2023. The peak day was on 22nd December 2023 (5427 IFR flights). Satuday's were the busiest days throughout this month with an average of 5325 IFR flights per day.

Total Fifty Nine (59) ATFM measures were applied this month during periods of congestion at Delhi,Chennai and Mumbai Airport.

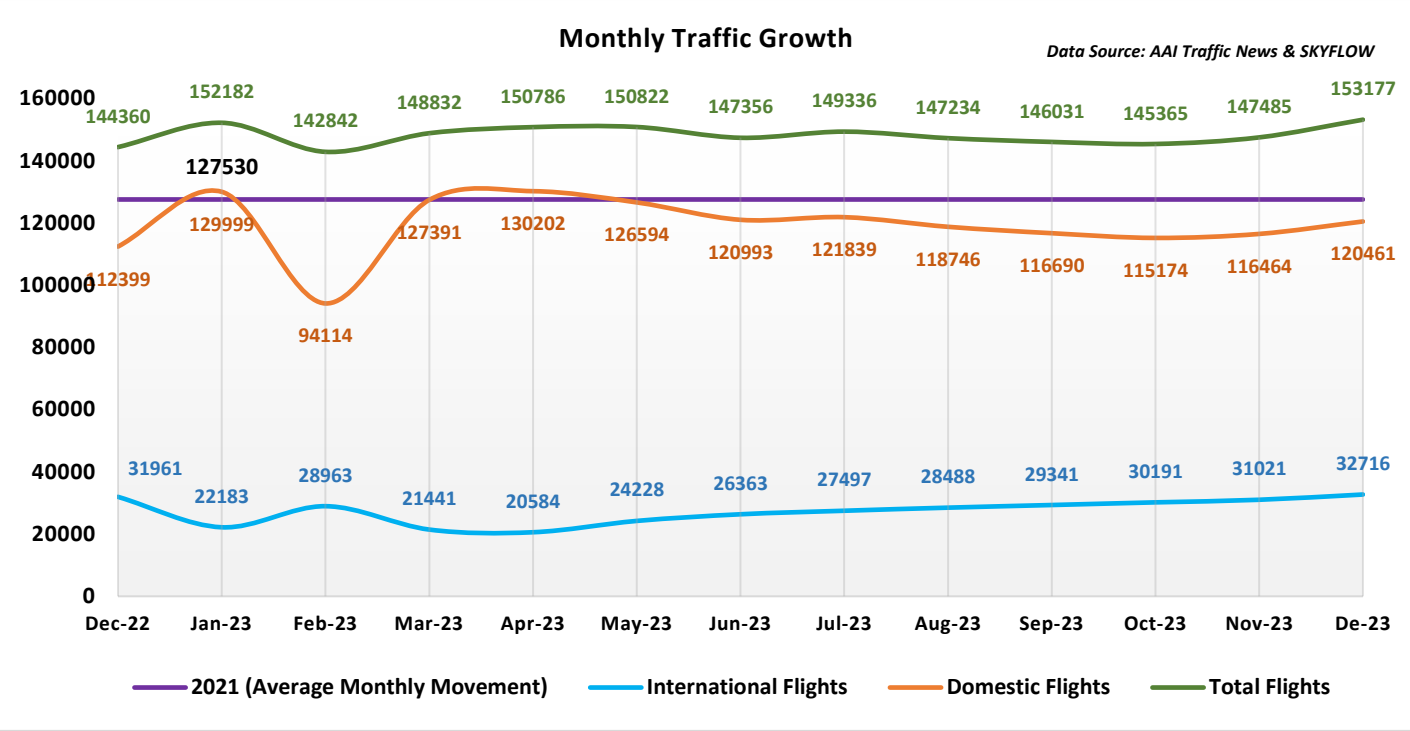


Figure 1: Monthly Traffic Growth

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

B. Traffic Analysis

I. Air Traffic Movement at Major Airports in India

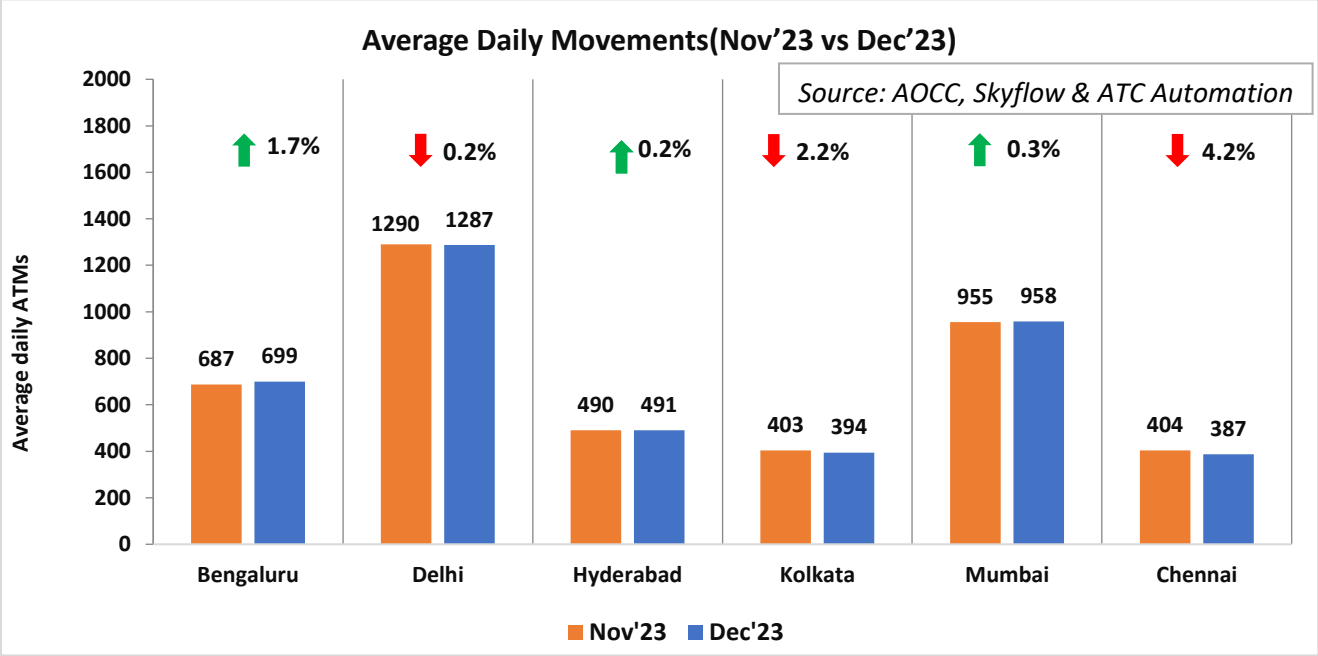


Figure 2: Average Daily Movements (Nov'23 vs Dec '23)

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

Airports\Year	Avg. Daily ATMs (YoY) for six major airports				
	Dec'19	Dec'20	Dec'21	Dec'22	Dec'23
Bengaluru	670	469	566	656	699
Delhi	1371	894	1247	1287	1287
Hyderabad	556	351	388	444	491
Kolkata	503	294	382	385	394
Mumbai	908	523	765	887	958
Chennai	497	283	342	350	387

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

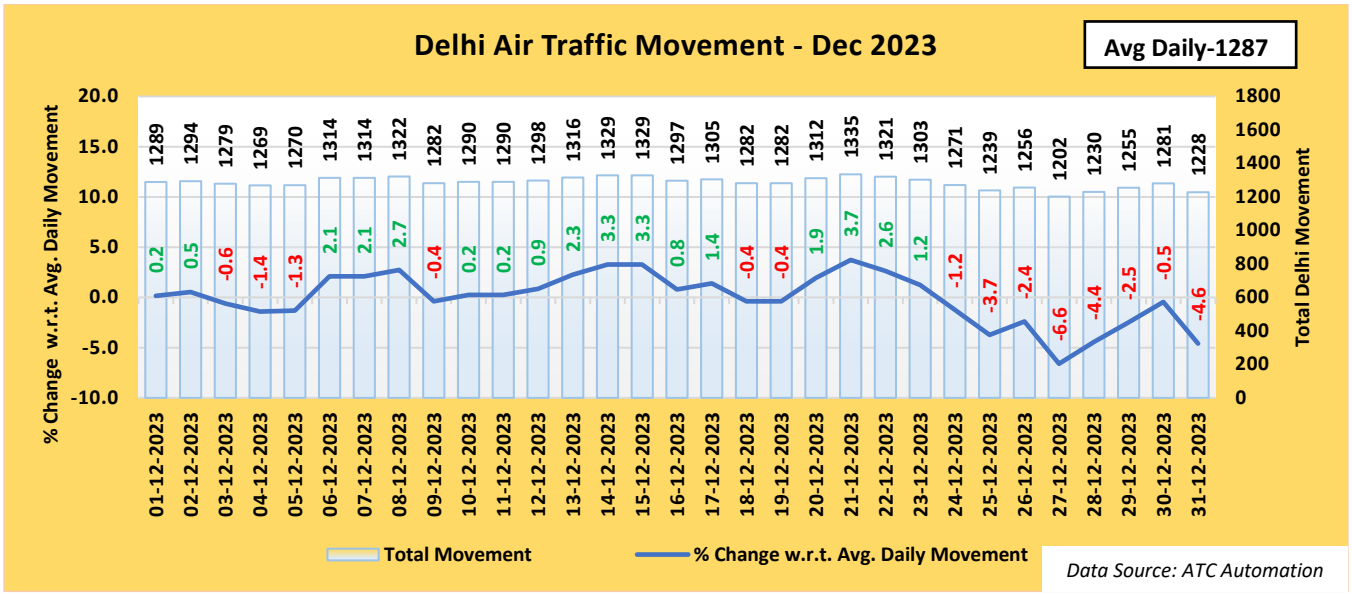


Figure 3: Air Traffic Movement for Delhi –Dec 2023

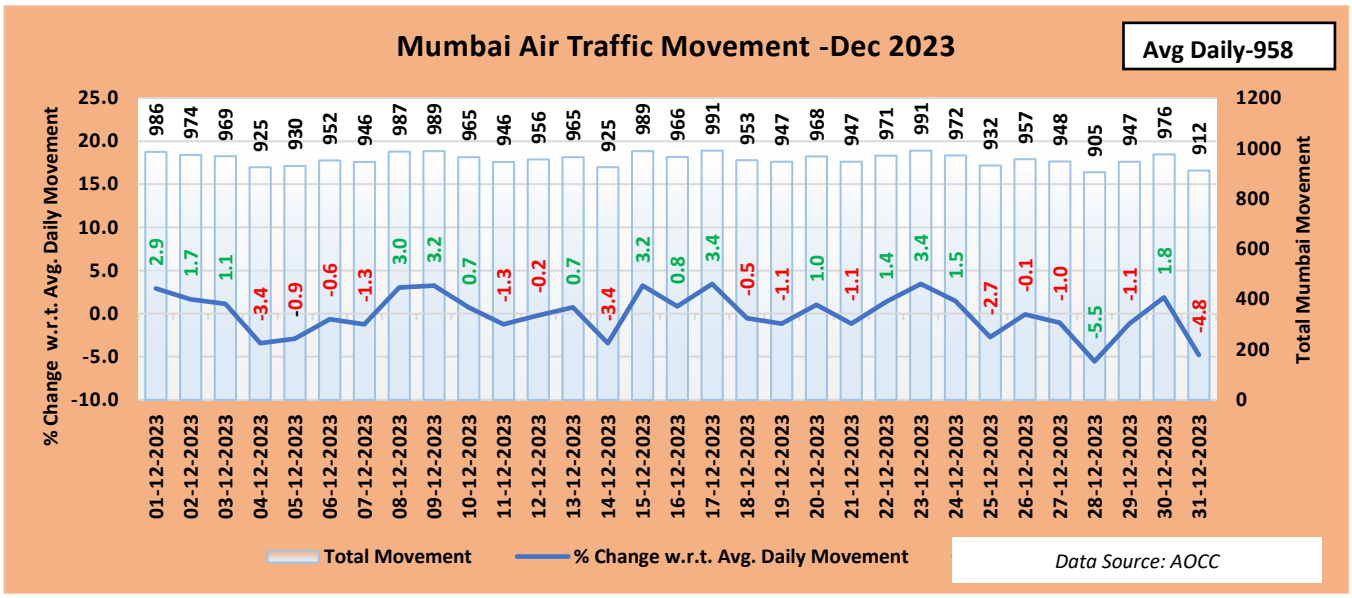


Figure 4: Air Traffic Movement for Mumbai - Dec 2023

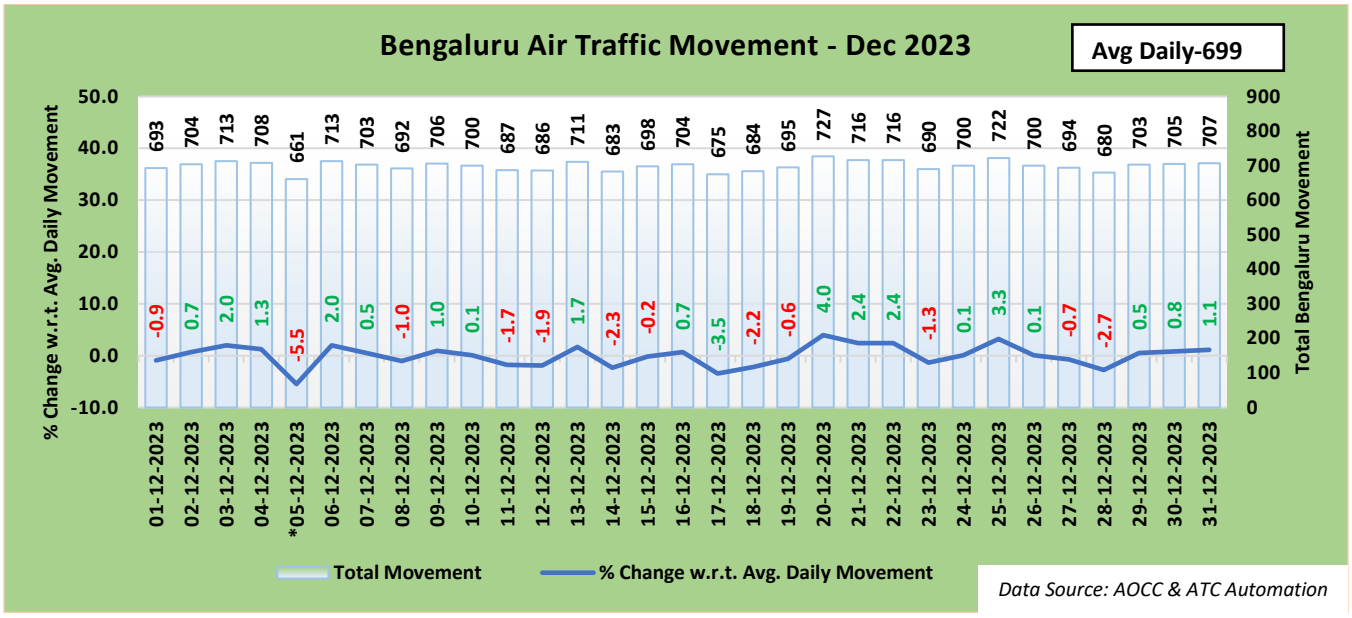


Figure 5: Air Traffic Movement for Bengaluru – Dec 2023

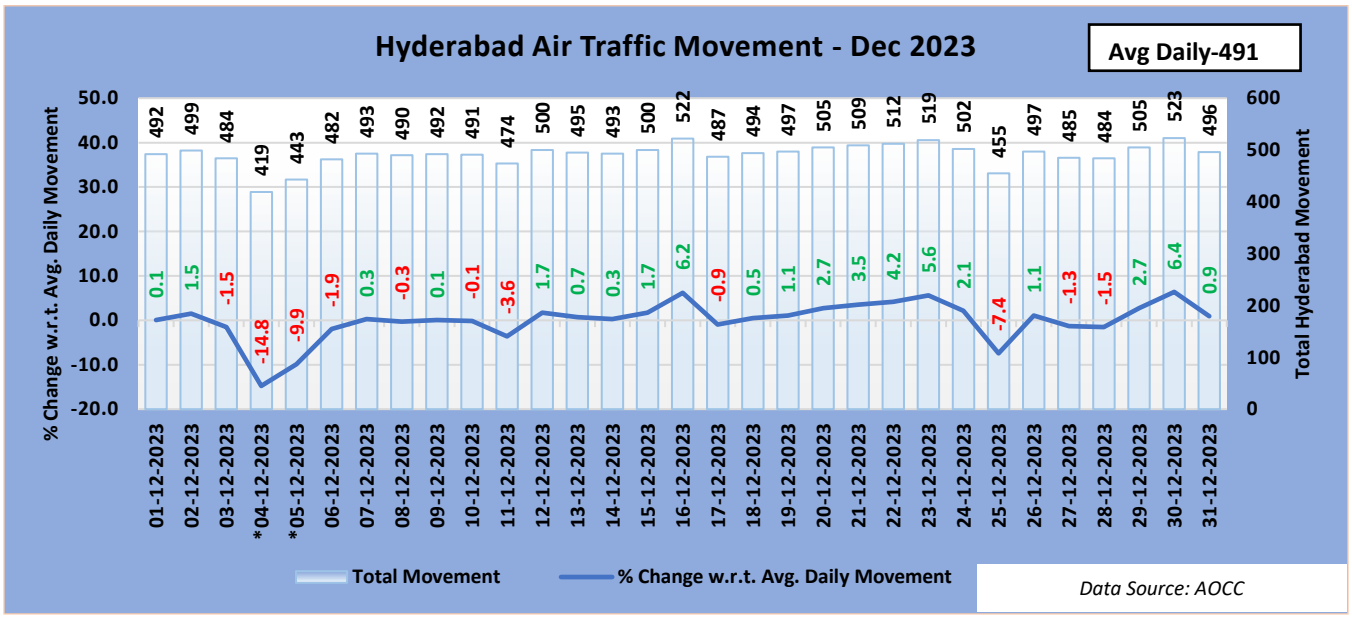


Figure 6: Air Traffic Movement for Hyderabad - Dec 2023

Low traffic on 04.12.2023 and 05.12.2023 due Michuang cyclone landfall on east coast.

It can be concluded from the above charts that on 31st Dec 2023(month end), the ATM at Delhi and Mumbai saw a decline of 4.6% & 4.8% respectively whereas ATMs at Hyderabad and Bengaluru witnessed an increase of 1.1% and 0.9% respectively in comparison to the average daily movement for Dec'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 December 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.

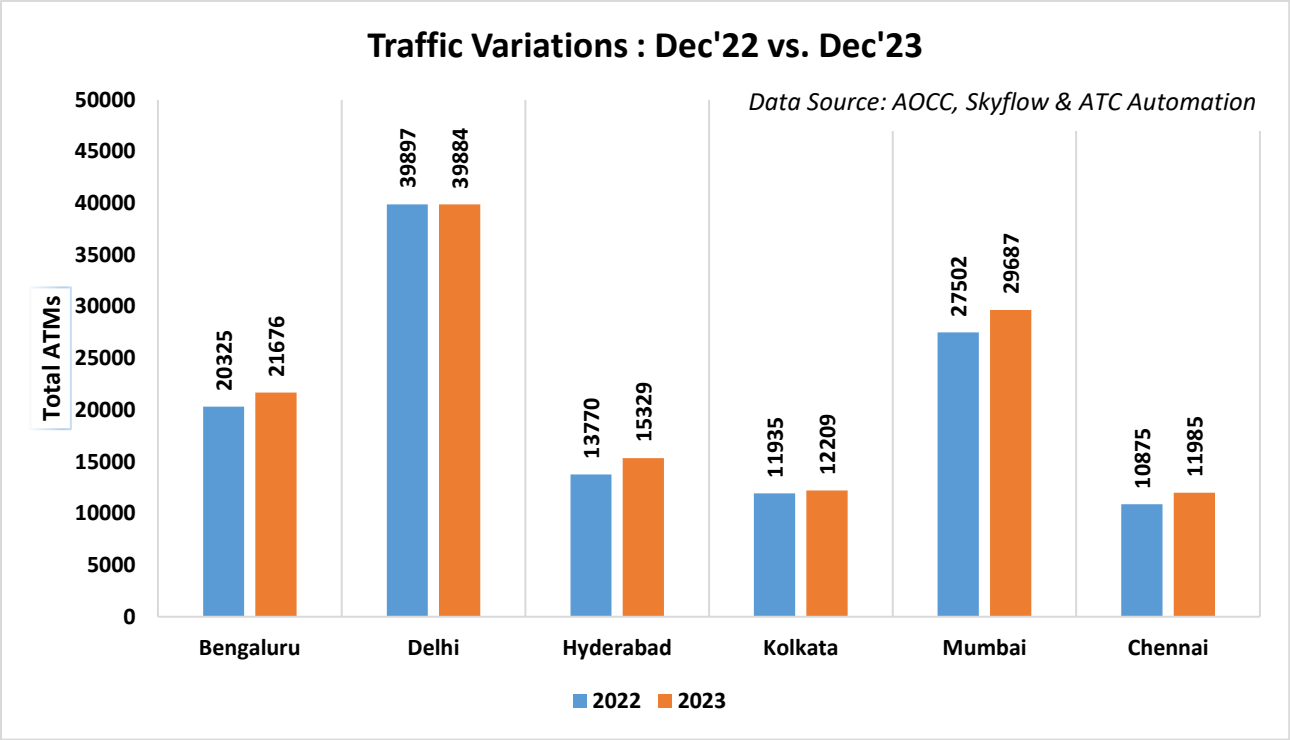


Figure 7: Traffic Variation (YoY)

III. Flight Operations – Airlinewise

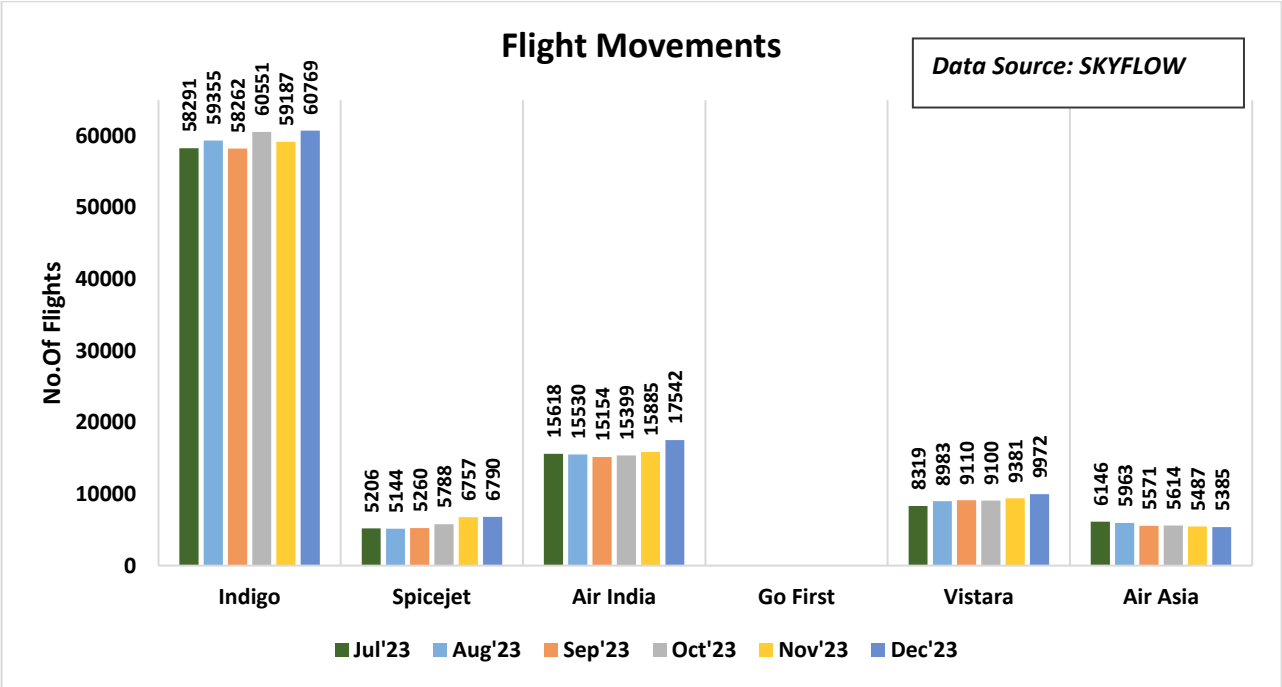


Figure 8: Flight Movements –Airlinewise

Inference:

1. Air India and Vistara Airlines have recorded an increase in the monthly average Flight movement in Dec'23 as compared to Nov'23 while Indigo, Spicejet and Air Asia Airlines have recorded a decline during the same period.Go first Airline has stopped operations from 3rd May 2023.

C. ATFM Post Operations – CDM Analysis

I. Introduction

Analysis Period **1st – 31st December 23**

Back Ground During the above mentioned period, **Eight (08)** ATFM measures were applied **for Delhi Airport, Forty Four (44)** ATFM measures were applied **for Mumbai Airport and Seven (07)** ATFM measures were applied **for Chennai** due to the following reasons as illustrated in the bar chart below:–

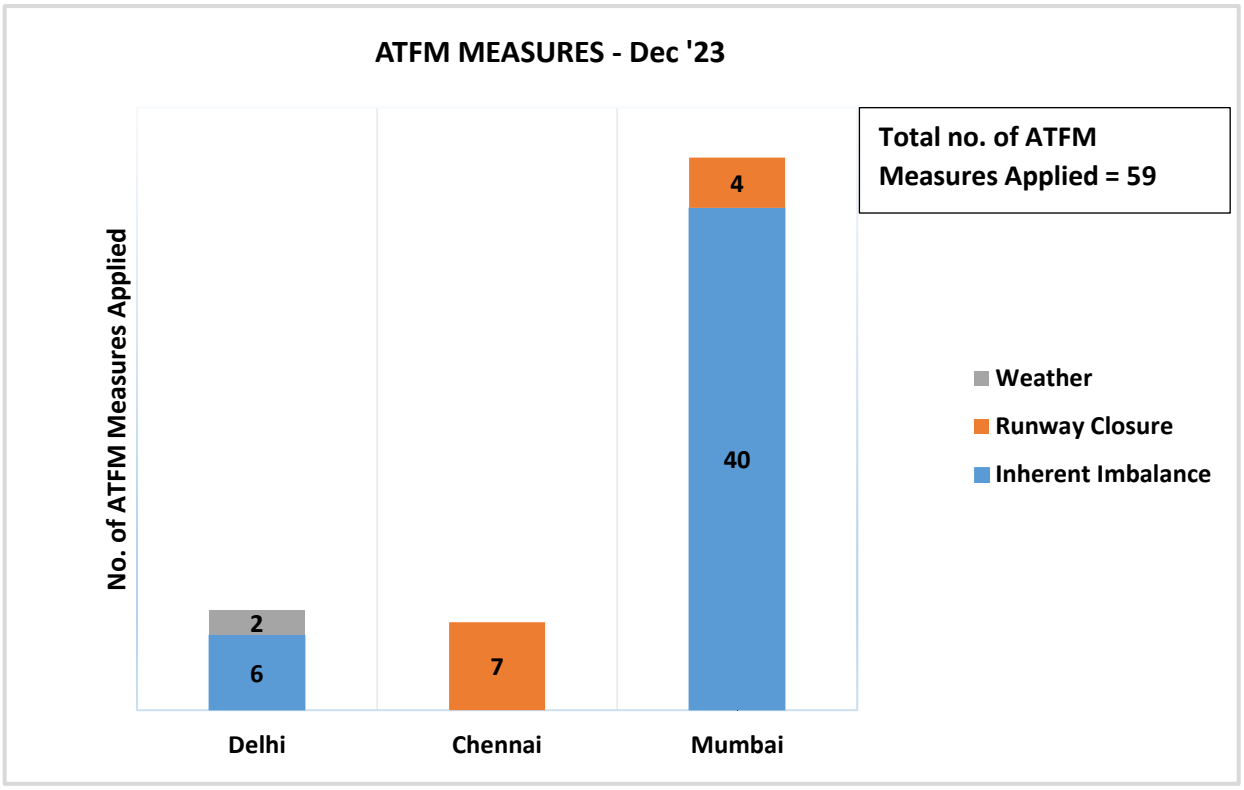


Figure 9: ATFM Measures –Dec ’23

II. ATFM Measures Overview

Constrained Airport	Delhi	Mumbai	Chennai
Number of ATFM measures applied	8	44	7
Average ATFM Ground delay(in min) due to measures*	16.6	14.2	18.8
Maximum ATFM Ground delay(in min) due to measures	52	85	35
% Compliance	64.9	76.7	70.5

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

Total Arrivals	3741
Total International Arrivals(exempted)	706
Total affected flights in scenario (Domestic Arrivals)	3035
Total Domestic Arrivals with zero ATFM delay	311
Total Domestic Arrivals with ATFM delay	2724

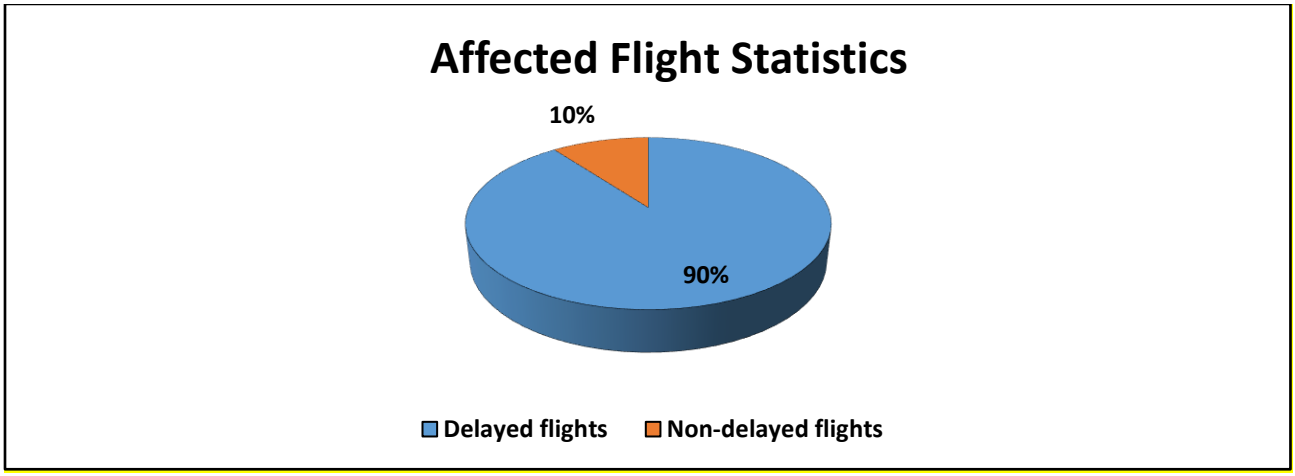


Figure 10: Affected Flight Statistics –Dec'23

III. Overall Compliance

Total arrivals	3741
Domestic arrivals	3035
Flights with complete data (ATOT)	2969
Flights with incomplete data	12
Flights Not Operated	54
Compliant*	2202
Non-Compliant	767

*Total No. of Revised CTOTs issued = 893 (Compliance calculation for flights which were issued revised CTOT is w.r.t. new CTOT issued)

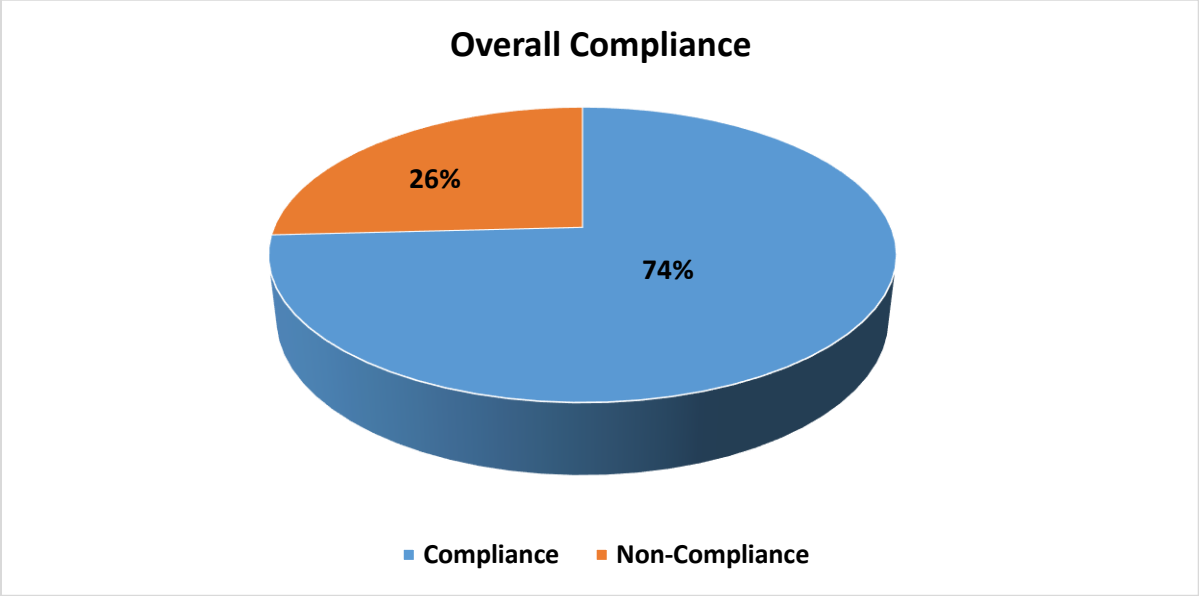


***Figure 11*: Overall Compliance – Dec'23**

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

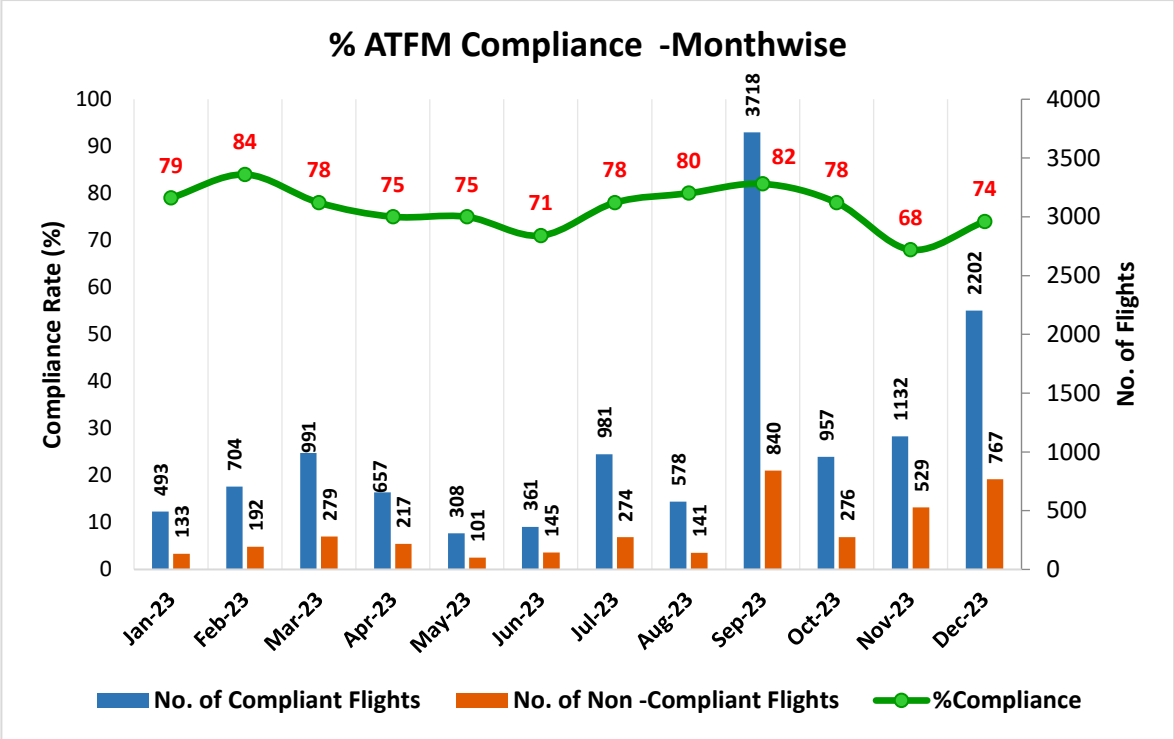


Figure 12: Compliance(Monthwise)

Inference

1. Out of the total arrivals captured(3741 flights) during the CDM scenario for the constrained Airports, 81.1% of flights i.e. domestic arrivals(3035 flights) were candidates for ground delay(participating).
2. Out of these Domestic Arrivals(3035), 89.75% (2724 flights) are assigned ATFM ground delay.
3. Out of the total arrivals captured(3741 flights) to the constrained Airport during the ATFM scenario, only 72.8% of flights(2724 flights) were assigned ATFM Ground Delay.

IV. CTOT Compliance rate – Airportwise

MUMBAI FIR (76%)*	Compliant	Non Compliant	% Compliant
Ahmedabad	113	20	85%
Aurangabad	17	4	81%
Mumbai	40	23	63%
Bhuj	0	1	0%
Vadodara	15	9	63%
Bhopal	19	5	79%
Bhavnagar	2	1	67%
Diu	2	4	33%
Hirasar	27	7	79%
Indore	32	8	80%
Jabalpur	8	1	89%
Jamnagar	13	6	68%
Kandla	3	3	50%
Kolhapur	2	1	67%
Keshod	3	0	100%
Nagpur	32	10	76%
Pune	9	6	60%
Porbandar	0	2	0%
Shirdi	5	0	100%
Surat	4	2	67%
Udaipur	38	11	78%
KOLKATA FIR (70%)*	**Compliant**	**Non Compliant**	**% Compliant**
Prayagraj	5	2	71%
Agartala	1	1	50%
Siliguri	39	11	78%
Shillong	2	0	100%
Varanasi	38	20	66%
Bhubaneswar	35	12	74%
Kolkata	104	35	75%
Chakeri	9	5	64%
Durgapur	1	2	33%
Darbhanga	6	8	43%

Deoghar	1	0	100%
Gorakhpur	11	13	46%
Guwahati	42	19	69%
Gaya	4	0	100%
Hollongi	1	0	100%
Imphal	1	2	33%
Jharsuguda	3	0	100%
Khajuraho	0	2	0%
Aizawl	1	1	50%
Dibrugarh	3	3	50%
Dimapur	0	1	0%
Patna	27	16	63%
Ranchi	18	8	69%
Raigarh	0	1	0%
Raipur	33	2	94%
DELHI FIR (67%)*	**Compliant**	**Non Compliant**	**% Compliant**
Amritsar	11	10	52%
Bikaner	1	1	50%
Bhuntar	0	1	0%
Bareilly	1	1	50%
Chandigarh	31	27	53%
Dehradun	17	8	68%
Delhi	258	100	72%
Kangra	3	6	33%
Gwalior	3	1	75%
Jodhpur	4	8	33%
Jaipur	68	24	74%
Jaisalmer	6	3	67%
Jammu	13	7	65%
Leh	8	5	62%
Lucknow	51	19	73%
Pantnagar	1	3	25%
Shimla	2	1	67%
Srinagar	24	20	55%
Uttarlai	1	0	100%

CHENNAI FIR (77%)*	Compliant	Non Compliant	% Compliant
Hal Bangalore	0	1	0%
Bangalore	225	50	82%
Belgaum	2	4	33%
Bidar	0	1	0%
Vijayawada	5	1	83%
Coimbatore	48	7	87%
Kochi	72	12	86%
Calicut	14	1	93%
MOPA Goa	55	27	67%
Goa	63	45	58%
Hubli	3	2	60%
Hyderabad	133	43	76%
Begumpet Hyderabad	0	1	0%
Vijaynagar	2	0	100%
Kannur	4	1	80%
Madurai	19	4	83%
Mangalore	31	9	78%
Chennai	144	21	87%
Nanded	0	1	0%
Port Blair	19	10	66%
Salem	0	1	0%
Sindhudurg	2	6	25%
Tiruchirappally	8	5	62%
Thiruvananthapuram	28	4	88%
Visakhapatnam	11	7	61%

**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(74%) for the month are highlighted in red.

V. CTOT Compliance rate – Airlinewise

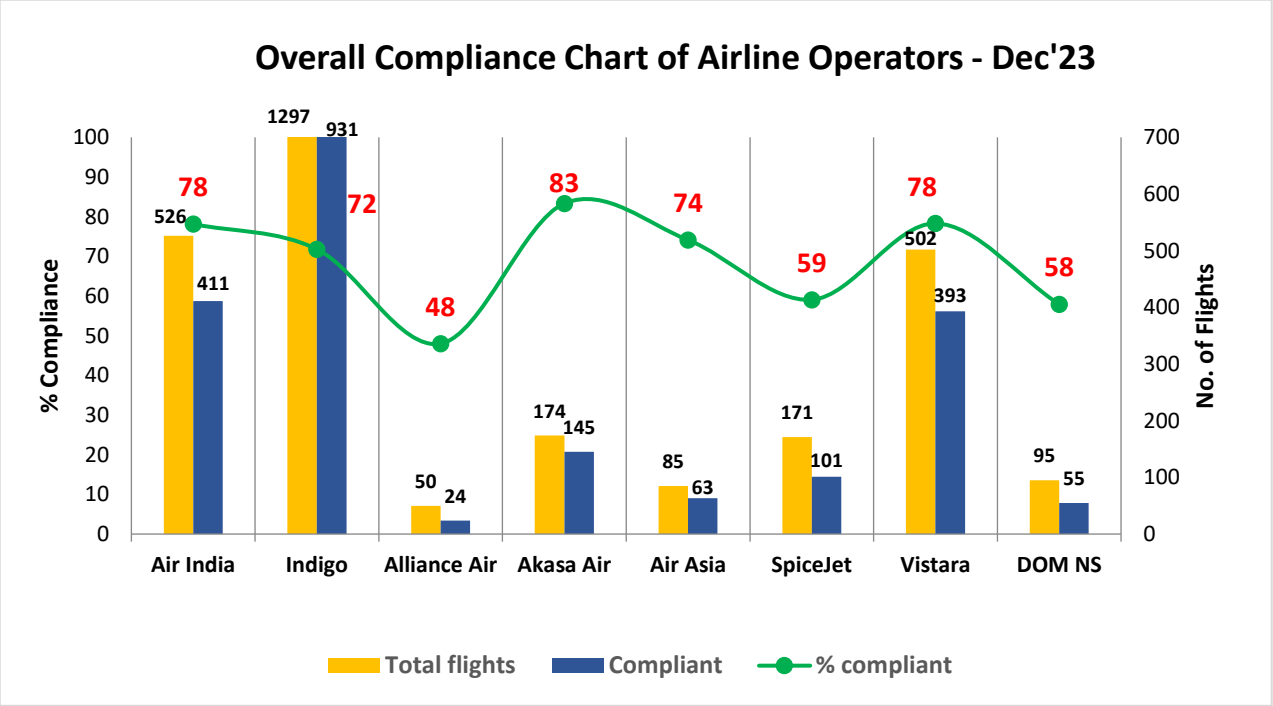


Figure 13: Airline wise Compliance –Dec'23

Inference

1. Out of the total domestic arrivals with complete data in the CDM scenario, 74% arrivals are compliant.
2. Chennai region record the highest compliance of 77% whereas Delhi region has the lowest percentage compliance of 67%.
3. Air India, Akasa Air and Vistara Airlines have a CTOT compliance higher than the average recorded compliance for the month of Dec '23.

VI. Reason For Non Compliance

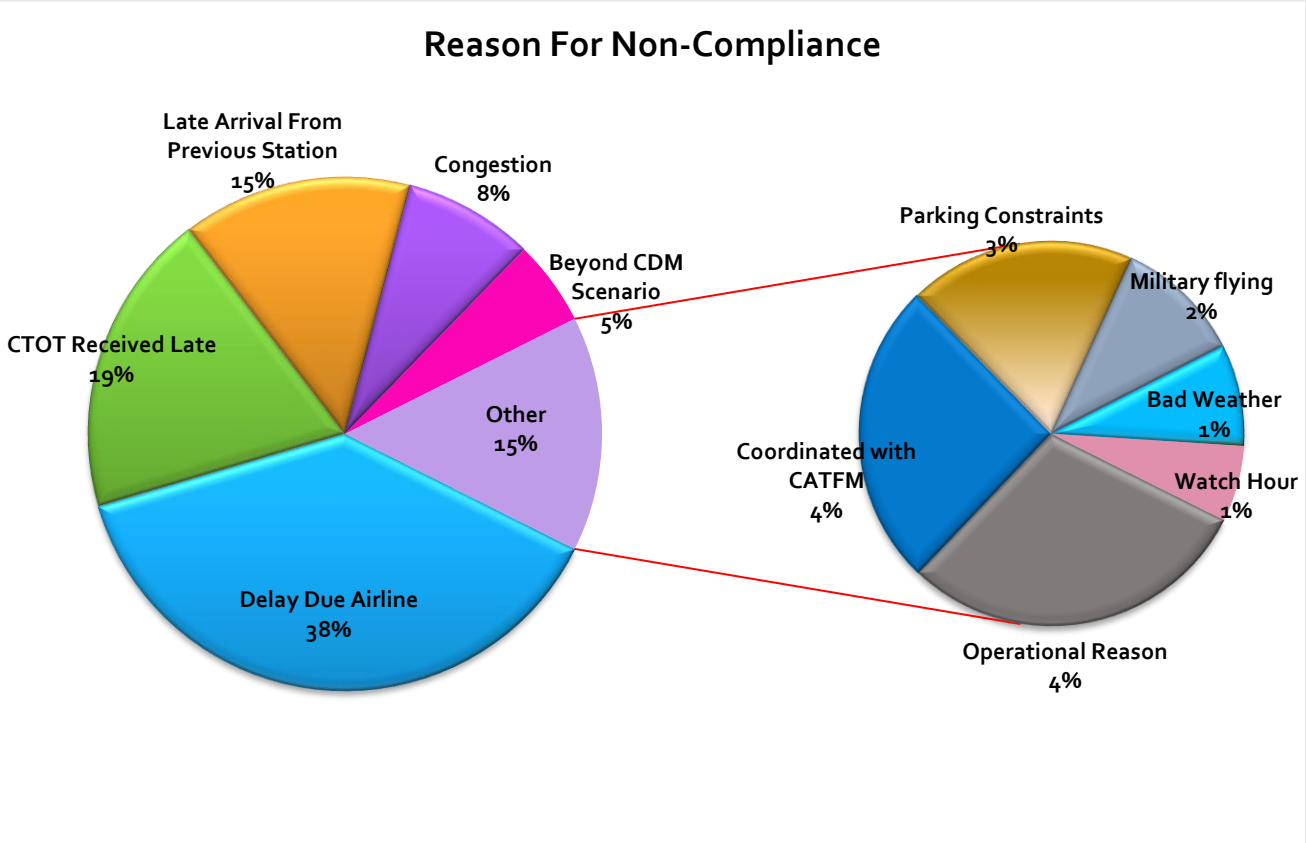


Figure 14: Reason for Non-Compliance as provided by FMPs

Inference:

1. 38 % of CTOT Non- Compliance was reported by concerned FMPs to be due to delay by Airlines.
2. 19% of the CTOT Non- compliance was reported by concerned FMPs to be due to late receipt of CTOTs and by the time the aircraft had already initiated pushed back or startup.
3. 15 % of the CTOT Non- compliance was reported to be due to late arrival of the aircraft from the previous station. Updated EOBTs of such flights was not available to ATFM unit leading to wastage of unused slots.
4. 8 % of CTOT Non- Compliance was reported by concerned FMPs to be due to congestion at airport of departure.

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 8.3, 9.9 and 8.8 minutes respectively.

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

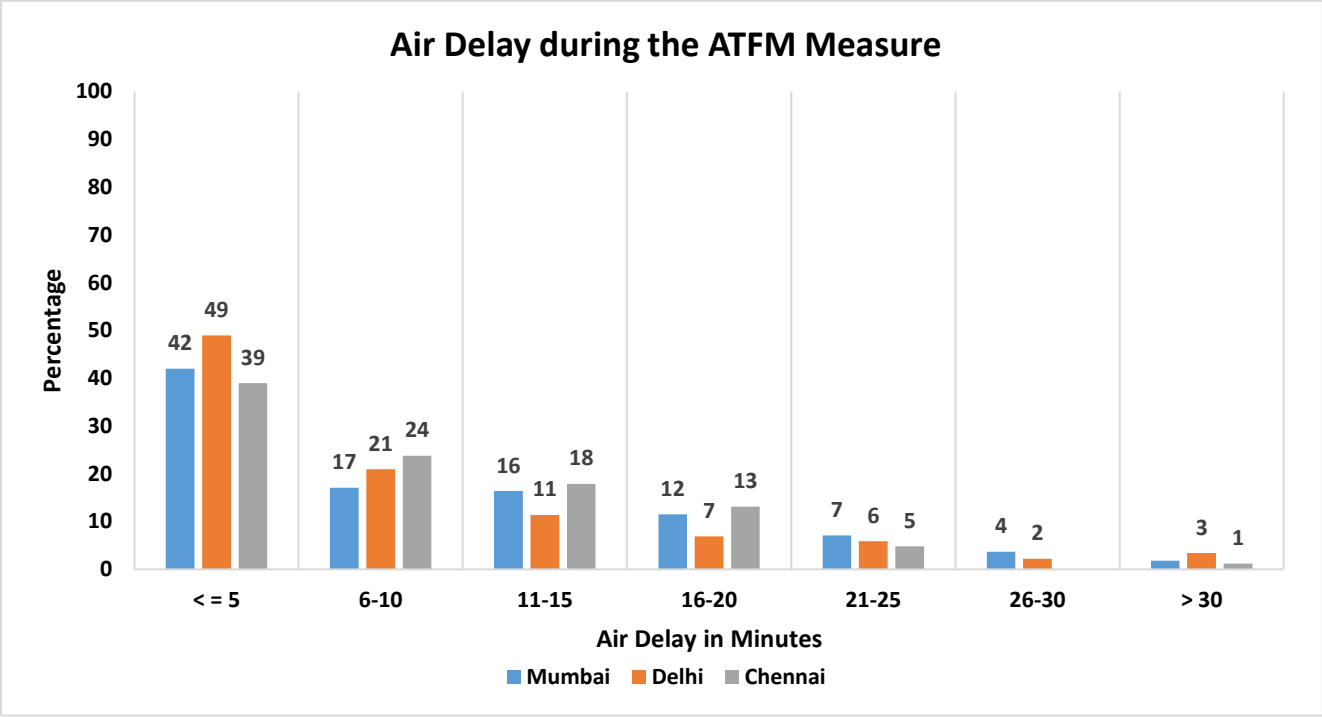


Figure 15: Air Delay distribution during the CDM period

Inference

1. 59% of domestic arriving flights to Mumbai had an Air delay of equal to or less than 10 minutes during the CDM period.
2. 70% of domestic arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period.
3. 63% of domestic arriving flights to Chennai 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 = ∑ (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 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)= 26620 mins

Total Air Delay (with no ATFM measures) = 67222 mins

Reduction in Air delay due to ATFM measures= (67222-26620) = **40602 mins**

Fuel Saving Calculation:

Total Fuel saved during the ATFM Measure: ***22,41,960.67 Kg***

Total reduction in CO_2 emission : 3.16(KgCO_2/kg fuel)* 22,41,960.67 **Kg** ***= 70,84,595.72 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*

Annexure-A

Compliance by Airlines with Flight Planning Requirements of Common Business rules(CBR)- December 2023

I. Introduction:

Accurate and timely input in respect of flight intent is paramount to the correct traffic demand projection and eventually effective ATFM implementation. FPLs remain the main source of tactical demand prediction for ATFM systems. Early filing of error free FPL helps in improving the lead time required for ATFM measures and reduces the number of unexpected flights(pop-up). This in turn helps in improving the accuracy of demand-capacity imbalance prediction and optimizes slot utilization.

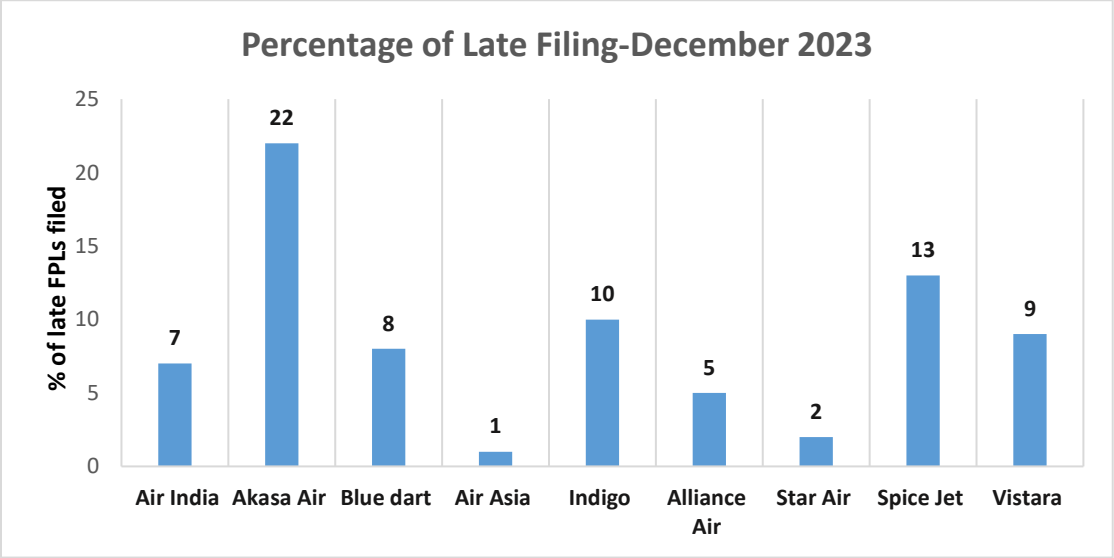
AIP India, ENR 1.9 section 4 on Flight Planning in the context of ATFM recommends Flight Planning requirements for all Airline Operators –

"a) Flight plans shall be submitted at least 3 hours before the estimated off block time (EOBT);
b) The window for filing FPL is between 3 Hours and 120 Hours (Five days) before the EOBT. Earlier filing of FPL will give a realistic demand data to the CCC and for better planning .Hence, the requirement of ATFM measures can be identified early. Late filing of a flight plan will lead to inaccuracies in predicting the demand and may lead to undesirable delay;"

II. Analysis

A. An analysis has been conducted to find out the difference between the flight plan filing time and filed EOBT for all the FPLs received at ATFM system from 1st December 2023 to 31st December 2023.
The purpose of the analysis is to monitor the compliance with provisions of AIP India, section 4, ENR 1.9 regarding Flight Planning requirements in the context of ATFM.

This flight plan filing requirement has been reiterated through the recently agreed ATFM common business rules (CBR) document and is recognized as a metrics to be monitored regularly for any improvement.



The table below lists number of filed flight plans (FPLs) with less than 3 Hours prior to EOBT:

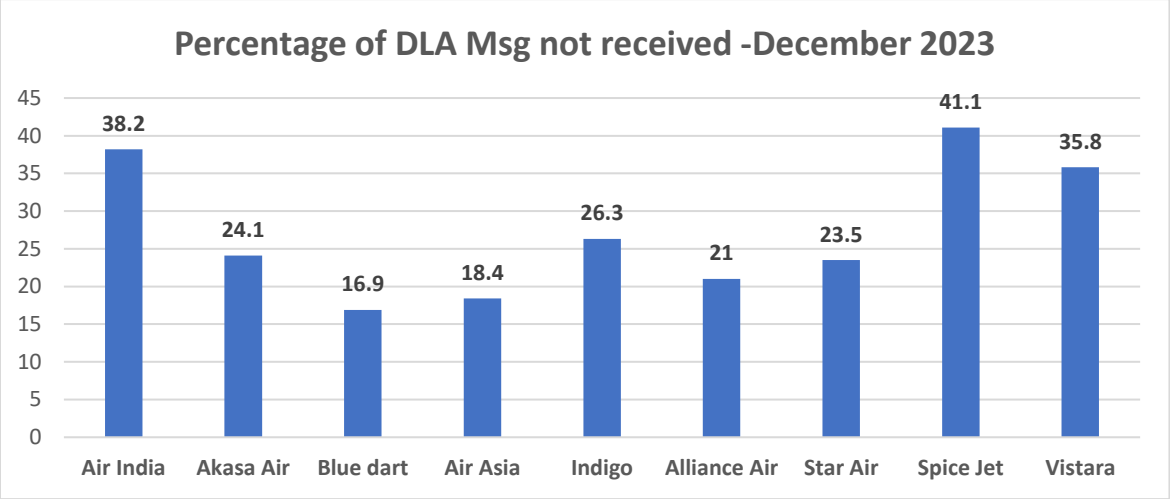
Name of Airline	Late Filed FPL	Total No. Of FPL	% Delayed Filing
Air India	937	13898	7
Akasa Air	768	3530	22
Blue dart	50	591	8
Air Asia	54	5396	1
Indigo	6377	61282	10
Alliance Air	151	3013	5
Star Air	21	1019	2
Spice Jet	883	6899	13
Vistara	896	9832	9
Total no. of FPLs for Scheduled Airlines	**10137**	**105460**	**10**

B. For the analysis of non-receipt of DLA (Delay) messages for flight plans filed, the EOBT of FPL received has been compared with Actual Take off time (ATOT)received through DEP(Departure)messages.
Thus, only those FPLs were considered for analysis for which DEP messages were available and no associated DLA messages was received.

The Table below lists number of flights for which no DLA message was received in December 2023.

{(EOBT of original FPL)- (ATOT received)} > 30 minutes)

Name of Airline	DLA Message not received	Total No. of flights considered for analysis	% of flights for which no DLA message was received
Air India	3615	9456	38.2
Akasa Air	603	2499	24.1
Blue dart	86	509	16.9
Air Asia	644	3484	18.4
Indigo	12071	45751	26.3
Alliance Air	355	1685	21.0
Star Air	83	353	23.5
Spice Jet	1362	3309	41.1
Vistara	2797	7794	35.8



C. For analysis of non-receipt of CNL (cancel) messages for December 2023, annulled FPLs were considered for which no CNL/DEP/DLA messages were received. A FPL gets annulled in SKYFLOW system, if it doesn't get activated through Dep message /surveillance data/ manual activation by FMP within a defined system parameter.

The table below lists the number of Flights for which no CNL Msg. was received in December 2023:

Name of Airline	**CNL message not received**	**No. of flights annulled**
Air India	83	89
Akasa Air	4	4
Blue dart	7	7
Air Asia	17	18
Indigo	467	479
Alliance Air	177	181
Star Air	8	10
Spice Jet	170	175
Vistara	6	6

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