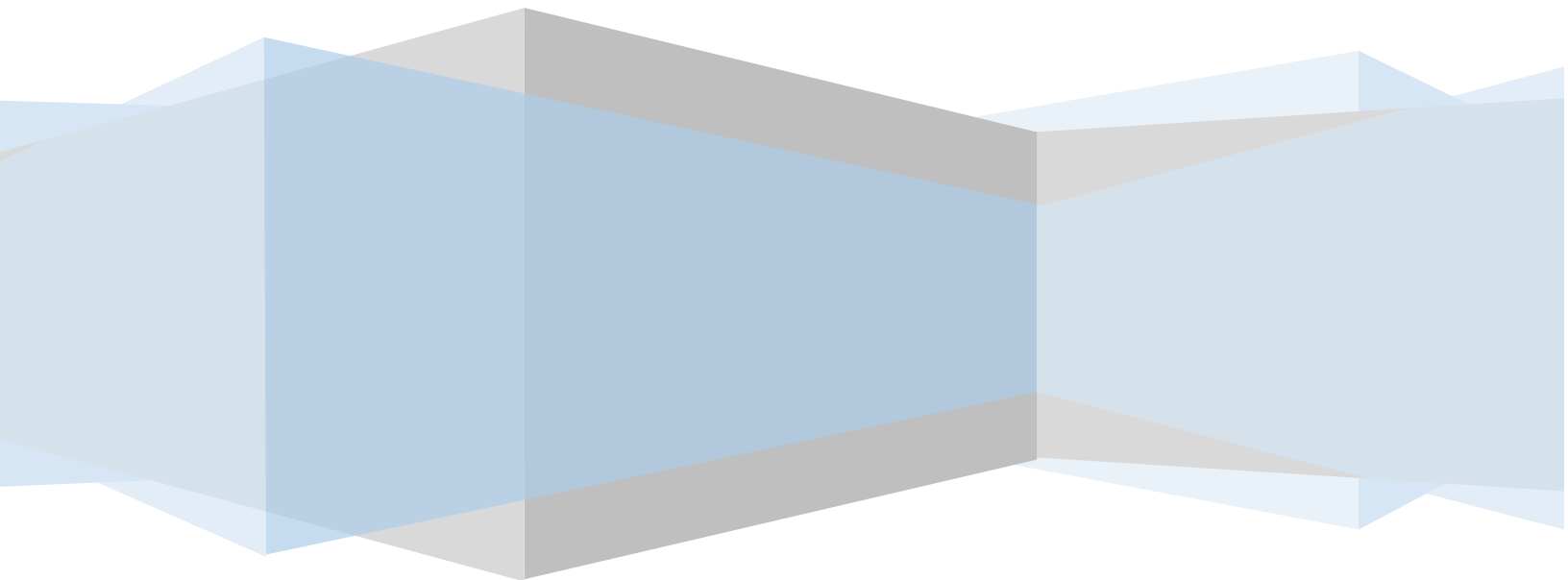


POST OPERATIONS ANALYSIS REPORT

December, 2022

CENTRAL COMMAND CENTER, C-ATFM, DELHI







Contents

A. Executive Summary	4
B. Traffic Analysis	5
I. Air Traffic Movement at Major Airports in India	5
II. Comparison of total ATMs (YoY) and Monthwise	8
III. Flight Operations – Airlinewise	9
C. ATFM Post Operations – CDM Analysis.....	10
I. Introduction	10
II. ATFM Measures Overview.....	11
III. Overall Compliance	12
IV. CTOT Compliance rate – Airportwise	14
V. Reason For Non Compliance.....	17
VI. CTOT Compliance rate – Airlinewise	18
VII. Air Delay during the CDM Scenario period	19
VIII. Tangible Benefits due to ATFM Measures	20
D. Glossary	22



List of Figures

Figure 1: Traffic Growth Post 1 st COVID wave	4
Figure 2: Average Daily Movements(Nov'22 vs Dec'22)	5
Figure 3: Air Traffic Movement for Delhi –Dec' 2022	6
Figure 4: Air Traffic Movement for Mumbai – Dec'22.....	6
Figure 5: Air Traffic Movement for Bengaluru – Dec'22.....	7
Figure 6: Air Traffic Movement for Hyderabad – Dec'22.....	7
Figure 7: Traffic Variation (YoY)	8
Figure 8: Flight Movements –Airlinewise	9
Figure 9: ATFM Measures –Dec'22	10
Figure 10: Affected Flight Statistics –Dec'22.....	11
Figure 11: Overall Compliance – Dec'22.....	12
Figure 12: ATFM Compliance(Monthwise)	13
Figure 13: Reason for Non-Compliance – Dec'22.....	17
Figure 14: Airline wise Compliance –Dec'22	18
Figure 15: Air Delay distribution during the CDM period.....	19



A. Executive Summary

Domestic and international air traffic** is estimated to have recorded an increase of 0.5 % and 5.8 % respectively in the month of December'22 as compared to November'22.

On average, the Indian Airports in the ATFCM area saw 4657 IFR flights per day. The peak day was on 23rd December'22 (4810 IFR flights). Friday's were the busiest days throughout this month with an average of 4738 flights per day.

Total Thirteen (13) ATFM measures were applied this month during periods of congestion at Delhi, Kolkata and Mumbai Airport.

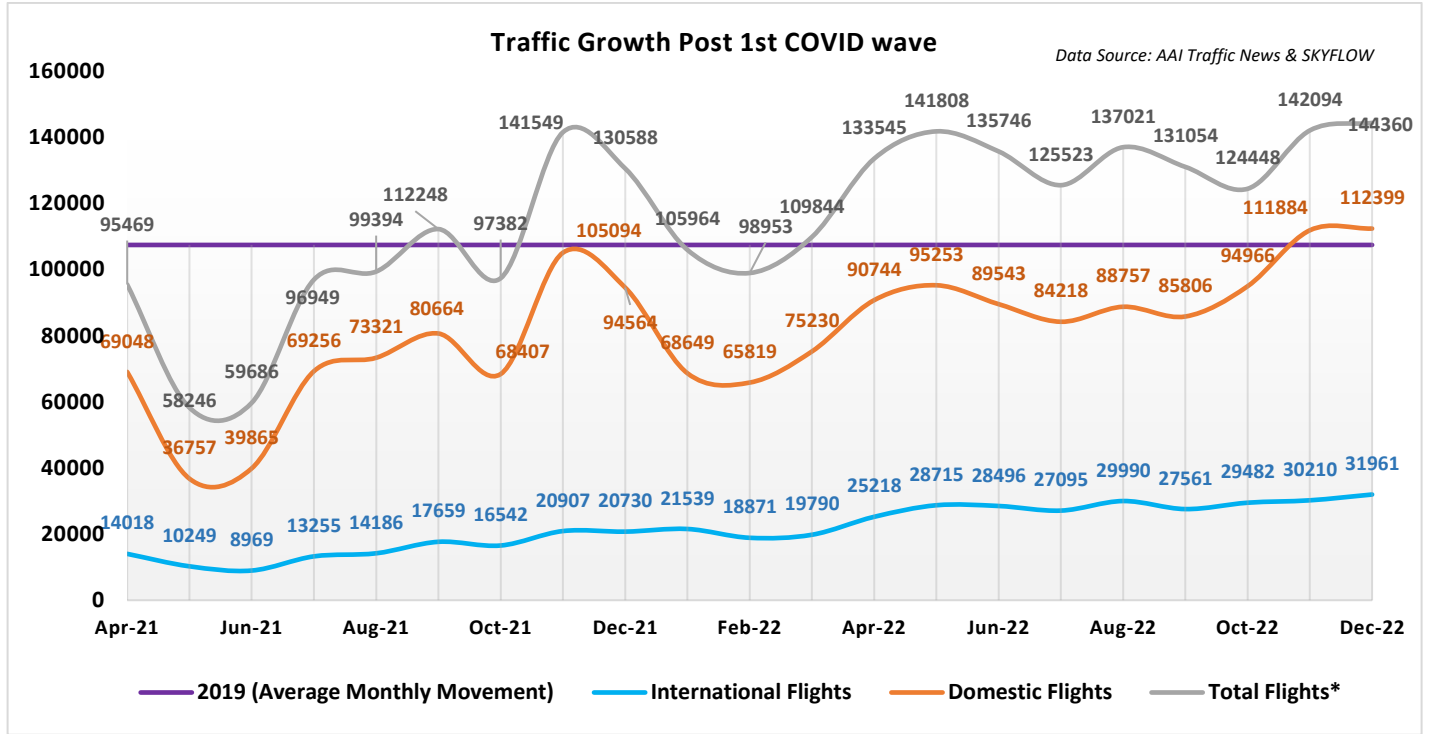


Figure 1: Traffic Growth Post 1st COVID wave

*Total Flights consists of Overflying traffic along with Domestic and International traffic

**Data for 22nd Dec'22 was inconsistent in skyflow system due technical issues.

The graph above depicts the Domestic and international Air traffic in Indian ATFCM Area during the last 21 months (Apr'2021 to Dec'2022). The traffic demand is visibly impacted by the Covid-19 infections through out the period.



B. Traffic Analysis

I. Air Traffic Movement at Major Airports in India

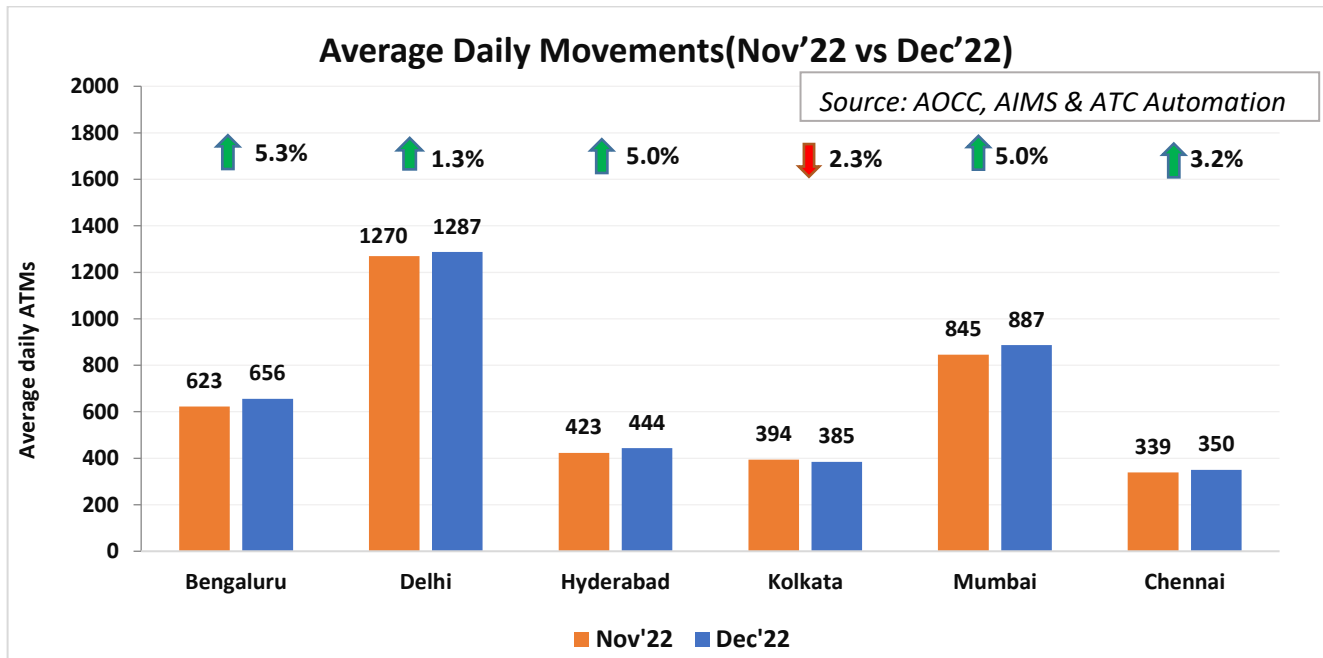


Figure 2: Average Daily Movements(Nov'22 vs Dec'22)

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

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

Major Airports - Bengaluru ,Delhi, Hyderabad, Kolkata, Mumbai and Chennai recorded average daily movements 98%,93.9%,79.5%,76.5%,97.6% and 70.4% respectively of December **2019** levels.



Air Traffic Movement for each day in Dec'22 is plotted for Delhi, Mumbai, Bengaluru and Hyderabad Airport along with the percentage change w.r.t. Avg. Daily Movement for the same month.

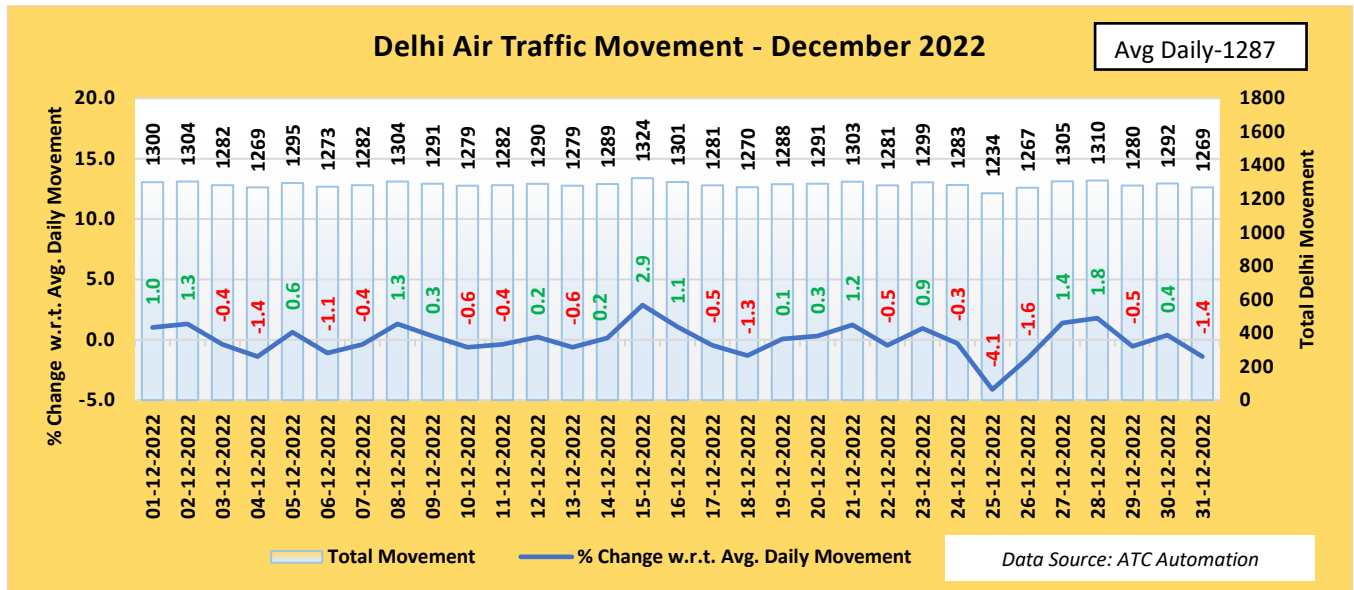


Figure 3: Air Traffic Movement for Delhi –Dec’ 2022

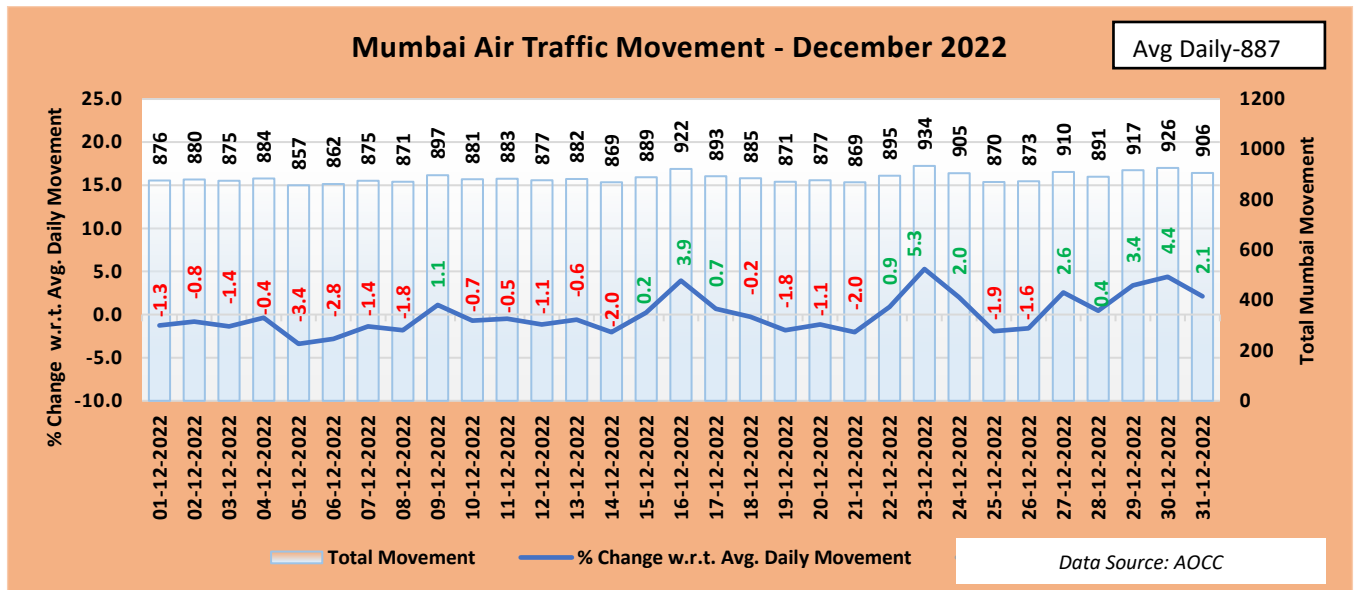


Figure 4: Air Traffic Movement for Mumbai – Dec’22

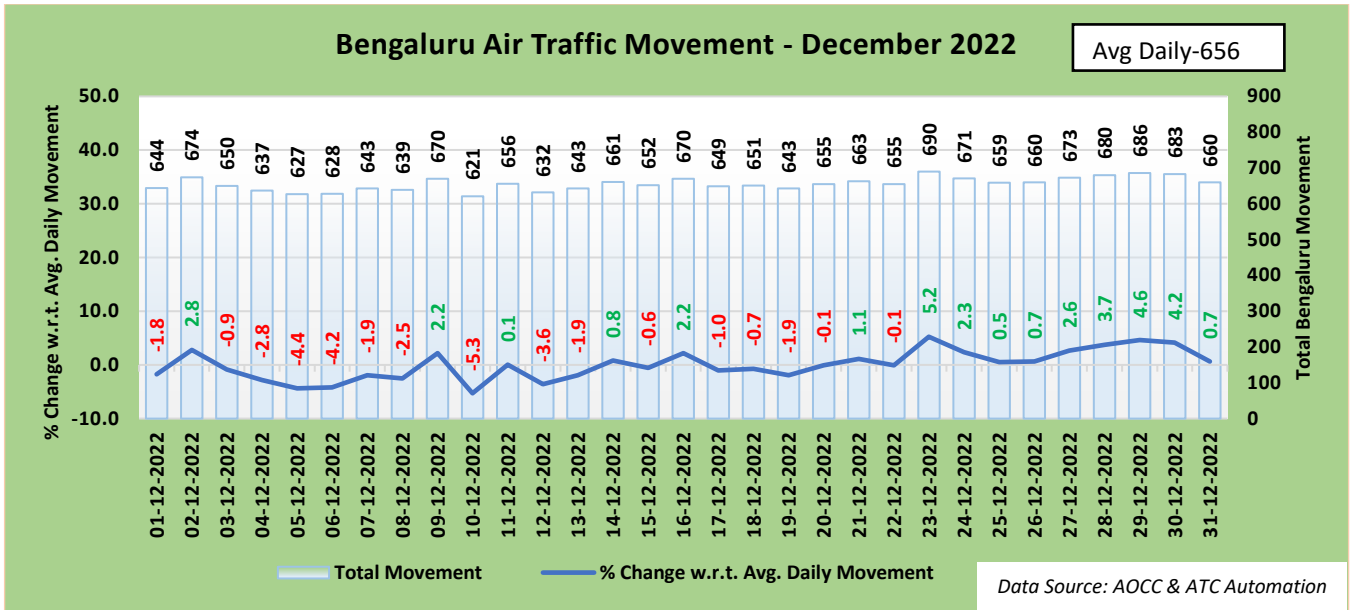


Figure 5: Air Traffic Movement for Bengaluru – Dec'22

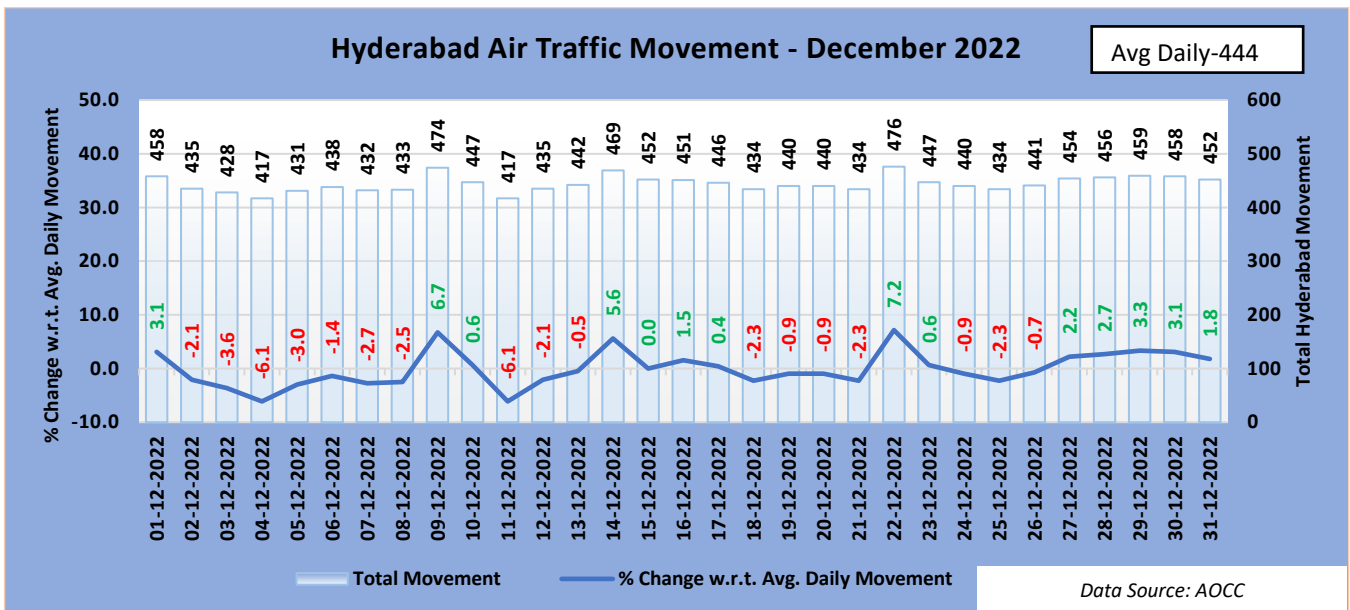


Figure 6: Air Traffic Movement for Hyderabad – Dec'22

It is evident from the above charts that on 31st December'22 the ATMs at Mumbai, Bengaluru and Hyderabad saw an increase of 2.1%, 0.7% and 1.8% respectively and a decrease of 1.4% at Delhi as compared to the average daily movement for the month of December'22.



II. Comparison of total ATMs (YoY) and Monthwise

The total Air traffic movement including Passenger and Combination of other flights i.e. All-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 '22 for two consecutive years. Air Traffic movement is also plotted Airline wise for the last six months for the major Scheduled Operators.

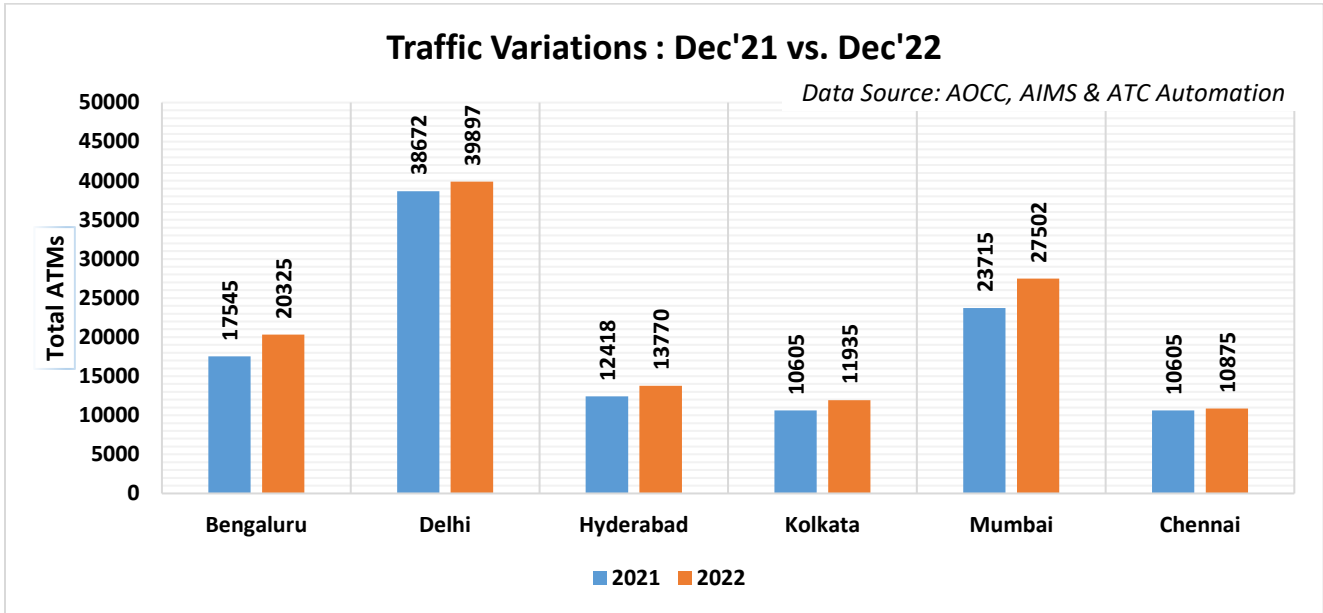


Figure 7: *Traffic Variation (YoY)*



III. Flight Operations – Airlinewise

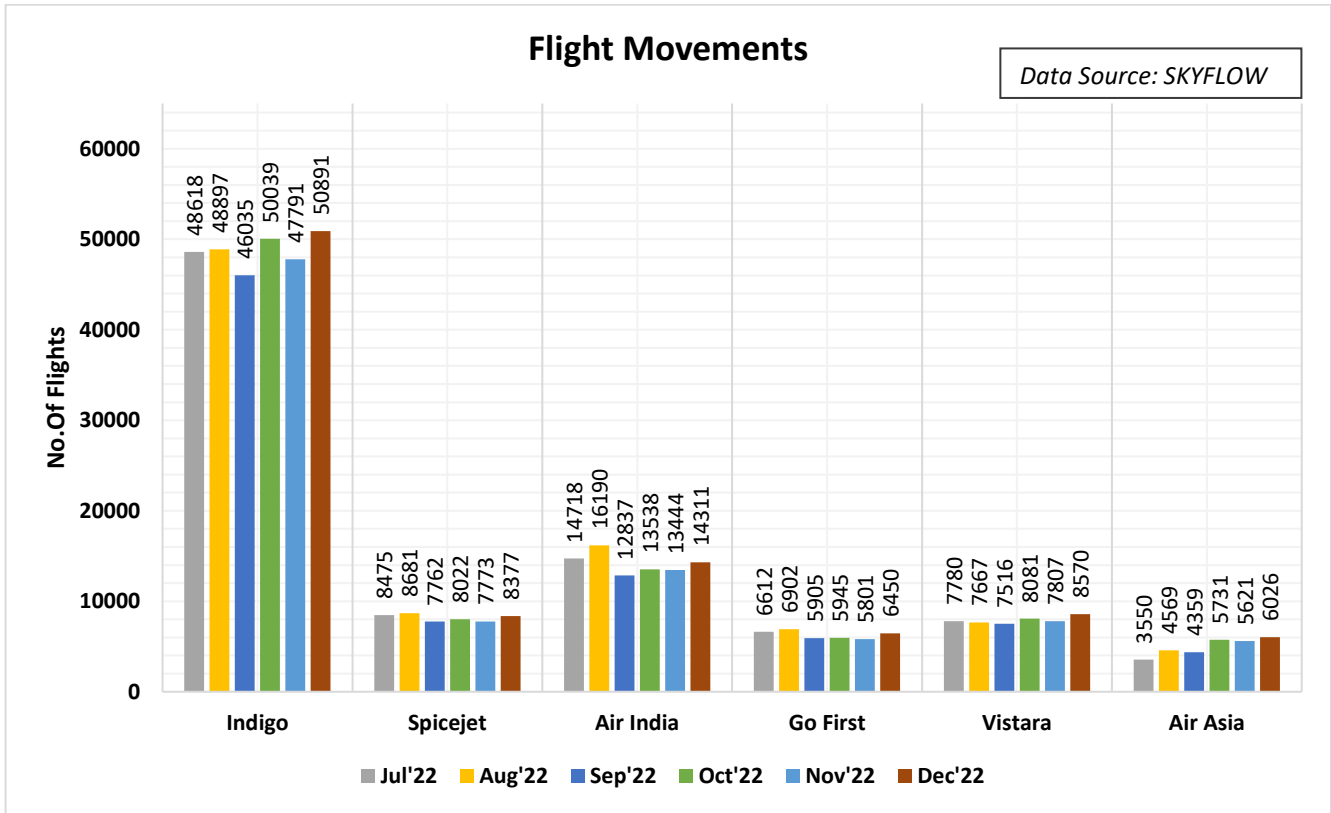


Figure 8: Flight Movements –Airlinewise



C. ATFM Post Operations – CDM Analysis

I. Introduction

Analysis Period 1st – 31st December'22

Back Ground During the above mentioned period, **seven (07)** ATFM measures were applied for **Delhi Airport**, **five (05)** ATFM measures were applied for **Mumbai Airport** and **one (01)** ATFM measure was applied for **Kolkata Airport** due to the following reasons as illustrated in the bar chart below:-

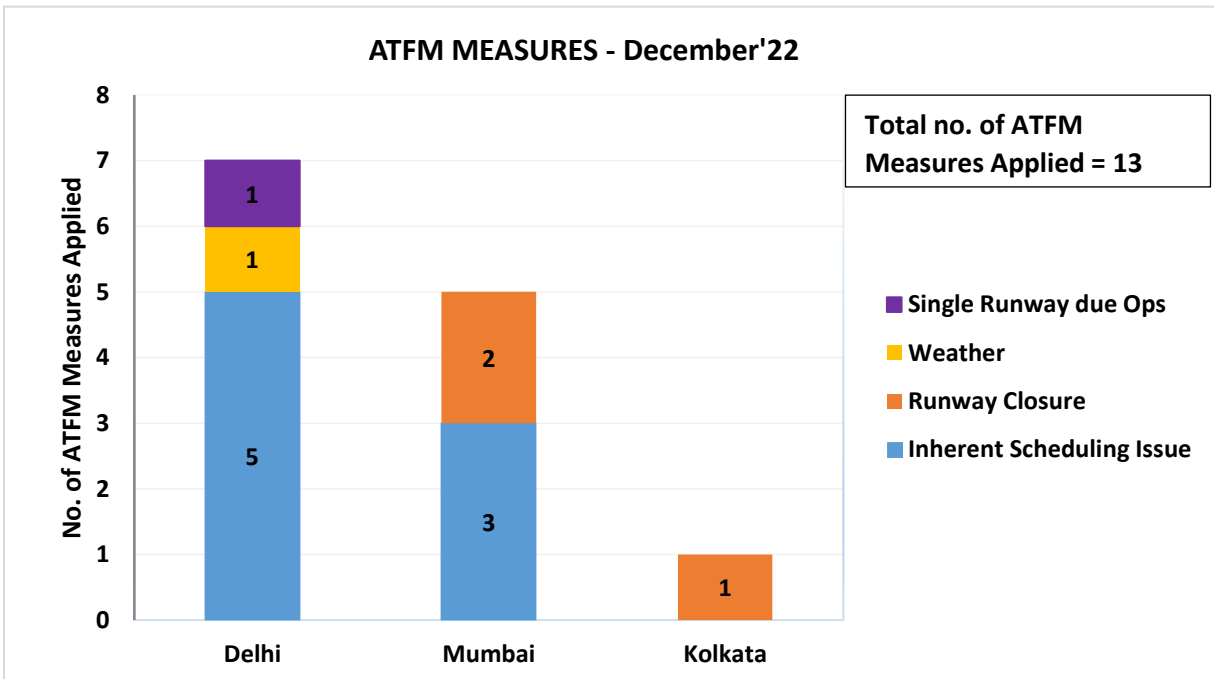


Figure 9: ATFM Measures –Dec'22



II. ATFM Measures Overview

Constrained Airport	Delhi Airport	Mumbai Airport	Kolkata Airport
Number of ATFM measures applied	7	5	1
Average ATFM Ground delay due to measures*	8.2	10.1	23
Maximum ATFM Ground delay due to measures	73	33	43
% Compliance	75	75	88

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

Total Arrivals	772
Total International Arrivals(exempted)	135
Total affected flights in scenario (Domestic Arrivals)	637
Total Domestic Arrivals with zero ATFM delay	120
Total Domestic Arrivals with ATFM delay	517

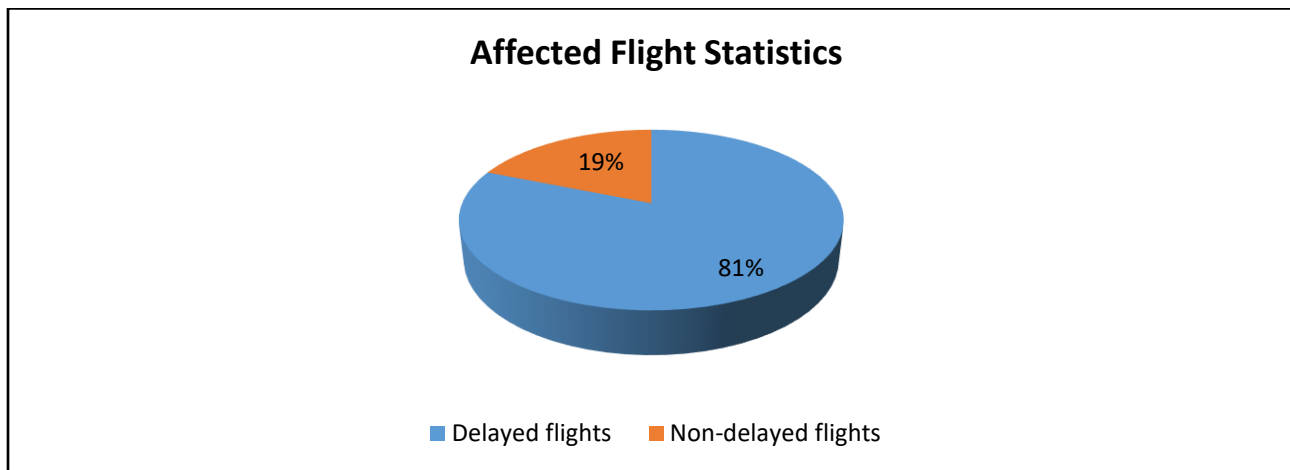


Figure 10: Affected Flight Statistics –Dec'22



III. Overall Compliance

Total arrivals	772
Domestic arrivals	637
Flights with complete data (ATOT)	622
Flights with incomplete data	9
Flights Not Operated	6
Compliant*	467
Non-Compliant	155

*Total No. of Revised CTOTs issued = 80 (Compliance calculation for flights which were issued revised CTOT is w.r.t. new CTOT issued)

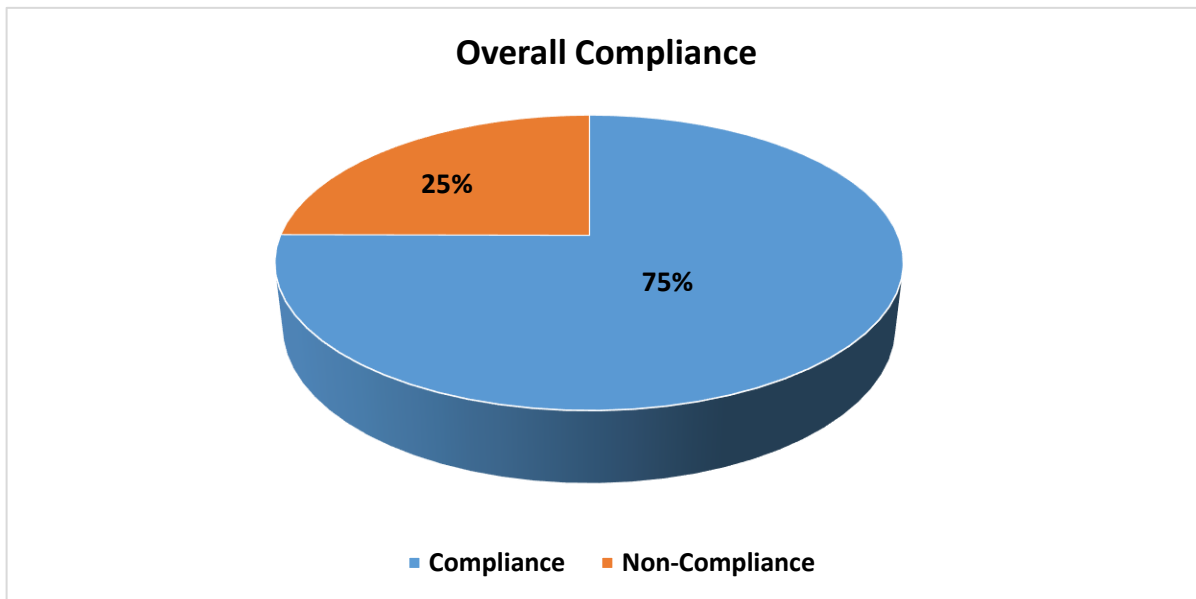


Figure 11: Overall Compliance – Dec'22

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

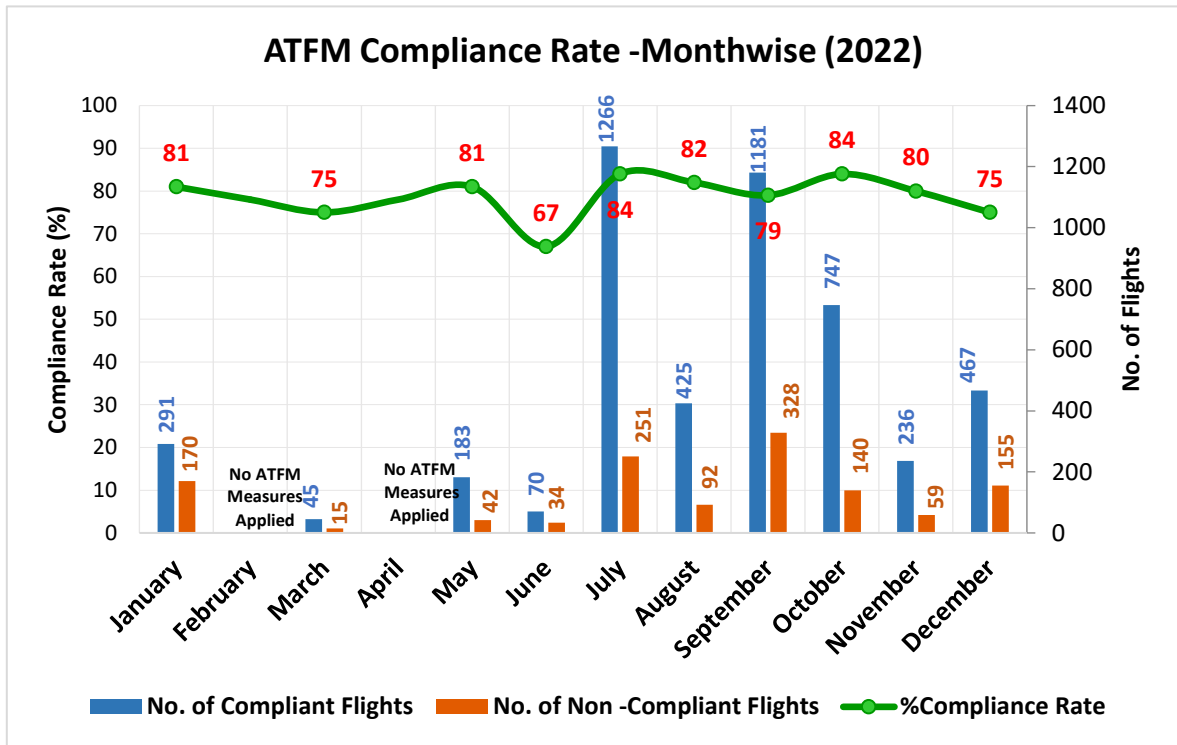


Figure 12: ATFM Compliance(Monthwise)

Inference

1. Out of the total arrivals captured for the constrained Airports during the CDM scenario, 82% of flights i.e. most domestic arrivals, are participating.
2. Out of these Domestic Arrivals, 81% are assigned ATFM ground delay.
3. Out of the total arrivals captured to the constrained Airport during the ATFM scenario, only 67% of flights are assigned ATFM Ground Delay.



IV. CTOT Compliance rate – Airportwise

MUMBAI FIR (78%)*	Compliant	Non Compliant	%Compliant
Ahmedabad	19	5	79%
Aurangabad	3	1	75%
Mumbai	34	11	76%
Vadodara	4	0	100%
Bhopal	7	0	100%
Diu	1	1	50%
Indore	8	1	89%
Jabalpur	1	0	100%
Jamnagar	2	0	100%
Nagpur	9	0	100%
Pune	12	9	57%
Rajkot	7	2	78%
Shirdi	1	2	33%
Surat	1	0	100%
Udaipur	13	3	81%
KOLKATA FIR (79%)*			
Prayagraj	2	1	67%
Agartala	5	0	100%
Siliguri	11	5	69%
Varanasi	12	5	71%
Bhubaneswar	3	1	75%
Kolkata	20	4	83%
Chakeri	1	4	20%
Durgapur	4	1	80%
Darbhanga	3	0	100%
Gorakhpur	2	1	67%
Guwahati	15	6	71%
Imphal	1	0	100%
Jharsuguda	1	1	50%
Khajuraho	0	1	0%
Silchar	1	0	100%
Aizawl	1	0	100%



Dibrugarh	5	0	100%
Dimapur	1	0	100%
Patna	11	2	85%
Ranchi	12	0	100%
Raipur	7	0	100%
DELHI FIR (68%)*			
Agra	0	1	0%
Aligarh	0	1	0%
Amritsar	5	1	83%
Bikaner	1	0	100%
Bareilly	0	1	0%
Chandigarh	12	3	80%
Dehradun	13	4	76%
Delhi	20	7	74%
Kangra	1	0	100%
Jodhpur	5	4	56%
Jaipur	15	5	75%
Jaisalmer	3	3	50%
Jammu	0	4	0%
Ajmer	0	1	0%
Leh	1	0	100%
Lucknow	14	4	78%
Shimla	1	0	100%
Srinagar	7	7	50%
CHENNAI FIR (76%)*			
Hal Bangalore	0	1	0%
Bangalore	36	5	88%
Vijayawada	1	0	100%
Coimbatore	5	1	83%
Kochi	7	0	100%
Goa	19	14	58%
Hubli	1	1	50%
Hakimpet	1	0	100%
Hyderabad	17	10	63%
Madurai	3	2	60%



Mangalore	5	0	100%
Chennai	21	3	88%
Port Blair	2	0	100%
Sindhudurg	0	2	0%
Tirupati	1	0	100%
Tiruchirappally	1	0	100%
Thiruvananthapuram	5	0	100%
Visakhapatnam	4	0	100%
Yelahanka Air Force	0	1	0%

**FIR wise compliance rate*

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

V. Reason For Non Compliance

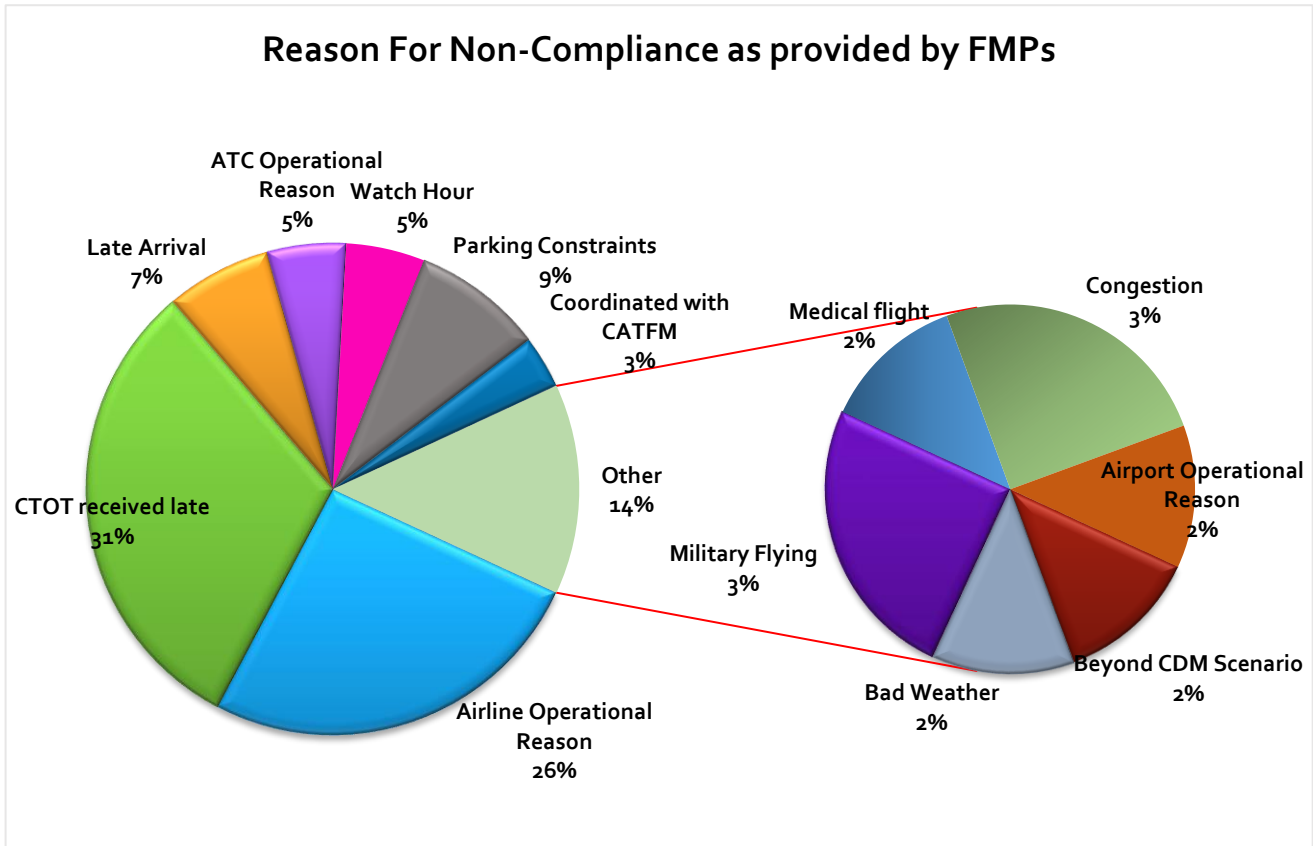


Figure 13: Reason for Non-Compliance – Dec’22

Inference

1. 31 % of the CTOT Non- compliance was due to late receiving of CTOTs and by then flights had initiated pushback/startup. Few ATFM measures were initiated at short notice and dissemination of CTOTs was delayed.
2. 26% of the CTOT Non- compliance as reported by FMP was due to Airline Operational reason. Flights EOBT was not revised with CCC, which lead to wastage of slots.
3. 9 % of CTOT Non-Compliance was reported to be due to parking constraints faced at the departure Airport.



VI. CTOT Compliance rate – Airline wise

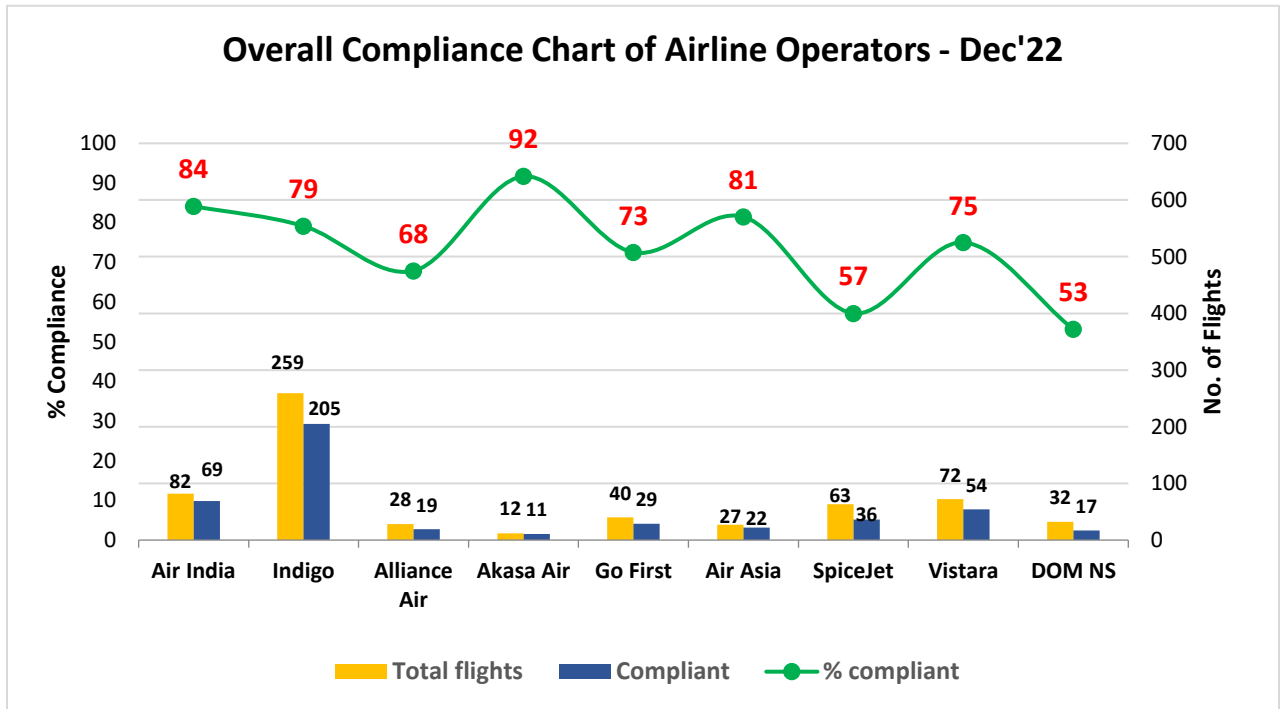


Figure 14: Airline wise Compliance –Dec'22

Inference

1. Out of the total domestic arrivals with complete data in the CDM scenario, 75% arrivals are compliant.
2. Kolkata 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 December'22.

VII. Air Delay during the CDM Scenario period

Average Air Delay to domestic arrivals* within the CDM Scenario period for Delhi, Mumbai and Kolkata is 7 minutes, 5 minutes and 8 minutes respectively.

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

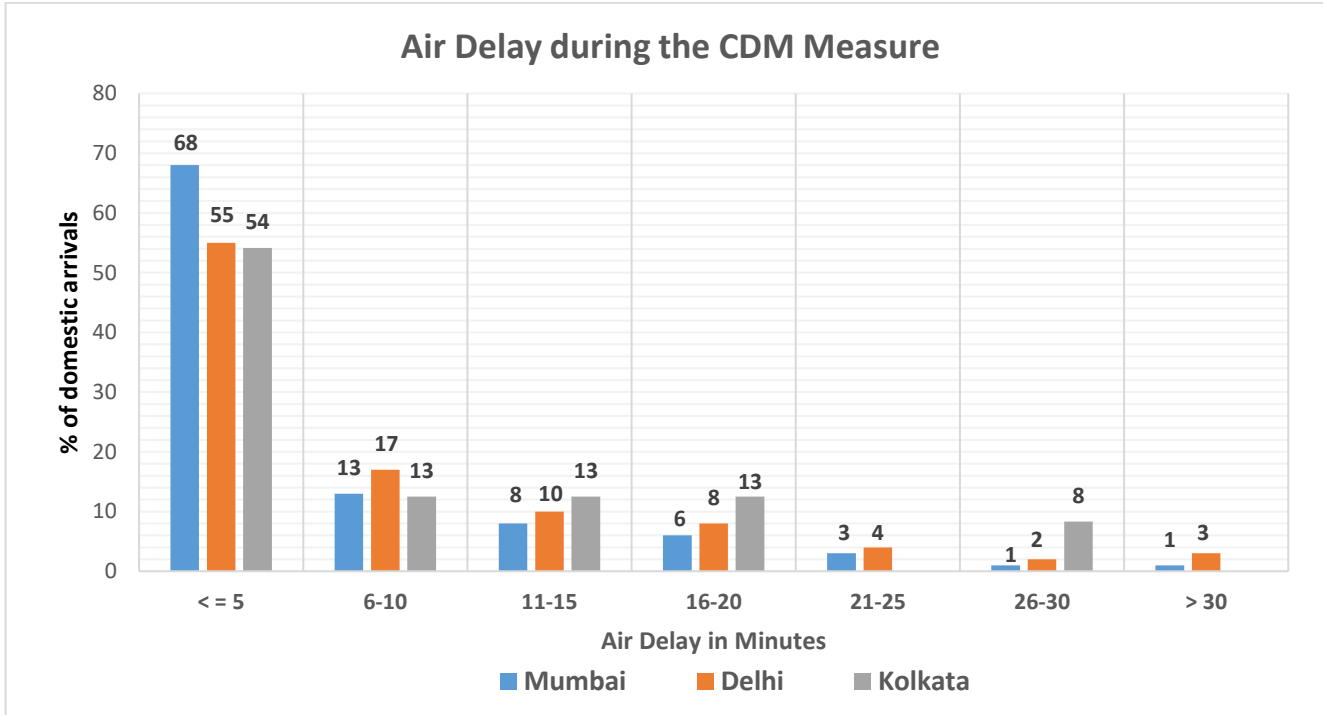


Figure 15: Air Delay distribution during the CDM period

Inference

1. 81% of domestic arriving flights to Mumbai had an Air delay of equal to or less than 10 minutes during the CDM period.
2. 72% of domestic arriving flights to Delhi had an Air delay of equal to or less than 10 minutes during the CDM period.
3. 67% of domestic arriving flights to Kolkata 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)= 2749 mins

Total Air Delay (with no ATFM measures) = 6802 mins

Reduction in Air delay due to ATFM measures= (6802-2749) = **4053 mins**

Fuel Saving Calculation:

Total Fuel saved during the ATFM Measure: **1,89,664.67 Kg**

Total reduction in CO₂ emission : 3.16(KgCO₂/kg fuel)* 1,89,664.67 Kg = 5,99,340.39 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
<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>