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Demand Management at Congested Airport in India

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Abstract

Congestion of Airport Brings to bear the need to manage Airport capacity more efficiently in order to meet the increasing demand for air transport. Whether this is achieved by increasing airport capacity or utilizing available capacity more efficiently, the inevitable increase in air traffic the world is facing will result in the need to manage effectively the allocation of slot at airport and protection of the environment. Congestion at airport leads to delay in arrivals and departure at airports, due to this flights cannot be started or completed on time as waiting in a queue to their turns for takeoff or landings or any other operations. This paper describes the congestion problem at Chhatarpati Shivaji international Airport(CSIA) Mumbai India, gives the mathematical expression to calculate average arriving delay per aircraft. Also gives capacity analysis.

Keywords: Demand management, congestion, and delay per aircraft.,capacity, VFR, IFR.

Introduction

A proxy that that can be used to indicate airport congestion is given by airport departure delays. Congestion indeed causes delays, but not all delays are caused by congestion. The airline companies themselves are by far the main contributors for delays, causing in Europe approximately 50% of late departures (Murillo and Carlier, 2006). Airports are considered to be responsible for delays in 19% of the cases, en route problems account for 11%, adverse weather is a serious factor with 13%, security procedures are responsible for 4% of the delays and a residual 3% for all other problems. Congestion of Airport Brings to bear the need to manage Airport capacity more efficiently in order to meet the increasing demand for air transport. Whether this is achieved by increasing airport capacity or utilizing available capacity more efficiently, the inevitable increase in air traffic the world is facing will result in the need to manage effectively the allocation of slot at airport and protection of the environment. This paper describes the congestion problem at Chhatarpati Shivaji international Airport Mumbai India, gives the mathematical expression to calculate average arriving delay per aircraft.

CSIA is the primary international airport in Mumbai, India. It has two intersecting runways. Both runways have been upgraded to Symbols F, which means they can put up larger aircraft like the Airbus A380. The airport can officially handle 36 flights per hour and intends to increase this to 48.About 58% of its late arrivals in 2008 to 2013 were delayed by 30 minutes or additional, although the delay in these arrivals is largely attributed to air congestion at a flight's origin.

Factors Affecting Capacity and Delay

Airfield Characteristics:

The physical characteristics and layout of runways, Taxiways and aprons are basic determinants of the ability to accommodate various types of aircraft and the rate at which they can be handled. Also important is the type of equipment(lighting, navigation aids, radar, and the like) installed on the airfield as a whole or on particular segments.

Airspace Characteristics:

The situation of the airfield in relation to other nearby airports and in relation to natural obstacles and features of the built environment determines the paths through the airspace that can be taken to and from the airport. Basically, the airspace geometry for a given airfield does not change over time. However, when there are two or more airports in proximity, operations at one airport can interfere with operations at another, causing the acceptance rate of one or both airports to suffer or requiring aircraft to fly circuitous routes to avoid conflict.

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Air Traffic Control:

The rules and procedures of air traffic control, intended primarily to assure safety of flight, are basic determinants of airfield capacity and delay. The rules governing aircraft leave-taking, runway possession, spacing of arrivals and departures, and the use of equivalent or converging runways can have an overall effect on throughput or can induce delays between successive operations. ATC rules and procedures have an especially important influence on capacity and delay at airfields where two or three runways may be in use at the same time or where there may be several arrival streams that must be merged on one final approachpath.

Meteorological Conditions:

Airport capacity is usually highest in clear weather, when visibility is at its best. Fog, low ceilings, precipitation, strong winds, or accumulations of snow or ice on the runway can cut capacity severely or close the airport altogether. Even a common occurrence like a wind shift can disrupt operations while traffic is rerouted to a different pattern; if the new pattern is not optimum, capacity can be reduced for as long as the wind prevails. A large airport with multiple runways might have 30 or more possible patterns of use, some of which might have a substantially lower capacity than the others.

Parameters Affecting Delay

1. Average deterministic arrival queuing delay per flight in Min at Airport i
2. The fraction of time during day t in which airport i operated under Instrument Flight Rules (IFR) conditions
3. The fraction of time during day t in which airport i operated under Visual Flight Rules (VFR) conditions
4. Airport arrival acceptance rate (number of arrivals per day) at airport i during day
5. The number of non-stop flight segments connected to airport i during day
6. Passenger delay
7. Flight delay

Mathematical Expression to Calculate Average Deterministic Arrival Delay

Dit = Qit + IFRit+VFRit + AARit + CONNECTit + Pd + Fd

(*Note: Validation IATA Guidelines For Demand and Capacity Management)

Where,

Dit = Average positive arrival delay against schedule per flight, in minutes, at airport i during day t,

Qit = Average deterministic arrival queuing delay per flight, in minutes, at airport i during day t,

IFRit = The fraction of time during day t in which airport i operated under Instrument Flight Rules (IFR) conditions VFRit= The fraction of time during day t in which airport i operated under Visual Flight Rules (VFR) conditions

AARit = Airport arrival acceptance rate (number of arrivals per day) at airport i during day t,

Connect'it = The number of non-stop flight segments connected to airport i during day t,

Pd= passenger delay

Fd =flight delay

Calculations For Delay

- Qit= 5 min per flight (As per standards)
  =2890 min
- IFRit= 621min (56 no/hr given as per runway configuration, Arrivals in 24 hour 578 nos)
- VFRit= 450min (77no/hr given as per runway configuration, Arrivals in 24 hrs 578 nos)
- AARit= 578 Nos/day (Arrivals of one day)
- CONNECTit= 1159 Nos Per day
- PD=PassengerDelay(i) =
  Pax(i)*(ActArrTime(i) - SchArrTime(i))
  =240 min
- FD=200 min
- Dit= 6138/Total no of flights
  = 6138/578

= 10.619 min against schedule per flight
(As it is less than 15 min it is under control)

(*Note: Arrivals And Departures in One Day At CSIA)

Capacity Analysis For CSIA

Capacity is a measure of the maximum number of aircraft operations which can be accommmdated on the airport or airport cmponent in an hour.

Parameters for capacity analysis

- Runway capacity
- Mix index
- Percent Arrivals (PA).
- Percent Touch and Go
- Runway-use Configuration

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Runway capacity:

Runway capacity is the number of aircrafts can accommodate on the runway. It can be calculated as follows

Runway capacity =

$$\frac{(AAR,ADR)1+(AAR,ADR)2+\cdots\ldots(AAR,ADR)n}{TOTAL\ NUMBER\ OF\ SLOTS\ FOR\ RUNWAY\ IS\ USED}$$

Mix Index

Mix index is a mathematical expression. It is the present of class C aircraft plus three times class D aircrafts. It can be written as follows:

$$\text{Mix index}=(C+3D)$$

Where,

C= Percent of airplanes over 12,500 Ibs but not over 300,000 lbs

D = Percent of airplanes over 300,000 lbs

Percent Arrival

The percent of arrivals is the ratio of arrivals to total operations. It is calculated as follows:

$$PA=\frac{A+1/2(T\&G)}{A+DA+(T\&G)}\times 100$$

Where,

A = number of arriving aircraft in the hour

DA = number of departing aircraft in the hour

T&G - number of touch and go's in the hour

Percent touch and go

Percent of touch and go's is the ratio of landings with an immediate takeoff to total operations. It is calculated as follows:

$$\text{(Touch \& Go)}=\frac{(T\ \&\ G)}{A+DA+(T\&G)}\times 100$$

Where,

A = number of arriving aircraft in the hour

DA = number of departing aircraft in the hour

T&G - number of touch and go's in the hour

Runway- Use Configuration

Runway-use configuration is the number, location, and orientation of the active runway(s), the type and direction of operations, and the flight rules in effect at a particular time.

AAR and ADR at CSIA

Table No-1: AAR and ADR at CSIA

SLOTS	AAR	ADR	(AAR+ADR)
12 AM TO 1AM	29	6	35
1 AM TO 2AM	7	20	27
2AM TO 3AM	9	27	36
3AM TO 4AM	8	21	29
4AM TO 5AM	14	11	25
5AM TO 6AM	9	33	42
6AM TO 7AM	6	54	60
7AM TO 8 AM	25	19	44
8AM TO 9 AM	27	30	57
9 AM TO 10AM	30	28	58
10 AM TO11AM	22	26	48
11AM TO 12PM	30	25	55
12PM TO 1PM	21	21	42
1 PM TO 2 PM	23	31	54
2 PM TO 3 PM	23	25	48
3PM TO 4 PM	29	21	50
4PM TO 5 PM	25	21	46
5 PM TO 6PM	36	30	66
6 PM TO 7 PM	35	30	65
7 PM TO 8PM	22	30	52
8 PM TO 9PM	24	32	56
9PM TO 10PM	40	18	58
10PM TO 11PM	46	14	60
11 PM TO 12AM	38	8	46
TOTAL	**578**	581	1159

*Source: www.csia.in

Result of Capacity Analysis

A. Runway capacity:

Total Number of movements per Hrs = 48.29 Nos

B. Mix Index:

Table -2: Mix Index

C	D	Mix index
98.56%	1.43%	102.85

C. Percent Arrival:

Table No-3: Percent Arrival

A(Arrival Rate)	D(Departure Rate)	T &G	% Arrival
24.08	24.42	48.29	49.89%

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D. Percent Touch and Go

Table No-4: Percent Touch and Go

A(Arrival Rate)	D(Departure Rate)	T &G	% Arrival
24.08	24.42	48.29	49.89%

E. Runway-Use- Configuration:

Fig: Runway Configuration of CSIA

Table 5-: Distribution According to Mix Index for Runway Configuration shown in fig 1

Mix index (C+3D) %	Hourly capacity (ops/Hr)		Annual Service Volume (Ops/yr)
	VFR	IFR	
0 To 20	98	59	230000
21 To 50	77	57	200000
51 To 80	77	56	215000
81 To 120	76	59	225000
121 To 180	72	60	265000

*Source: Advisory Circular For Capacity and Delay By FAA

Conclusion

Congestion at airport leads to delay in arrivals and departure at airports, due to these flights cannot be started or completed on time as waiting in a queue to their turns for takeoff or landings or any other operations. This paper analyses the congestion problem at Chhatarpati Shivaji international Airport Mumbai India, gives the mathematical expression to calculate average arriving delay per aircraft. As per data and calculations average arrival delay per aircraft is 10.619 min against schedule, but as per standards of IATA(International Air Transport Association) arriving delay per aircraft should not be more than 15 min against schedule hence the situation of CSIA is under control. As per the capacity analysis runway capacity obtained as 48.29 Nos per hour and as MIAL set a target of 48 aircraft movements an hour in an effort to reduce congestion at the airport.as calculated capacity and given are same its indicate that its need a proper management.

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