Arrival Delay Comparison of Airline Services

N.Sumathi, B.Arun
Dept of Aerospace Engineering Amrita School of Engineering, Coimbatore
Amrita Vishwa Vidyapeetham, India

***Abstract*: - Airside operations involve complex tasks carried out by a different department for some collective and competing interests. The significant factor that affects the Airside operations in an airport is flight scheduling practice under weather conditions. Aircraft awaiting delayed take-off with engines running would prove cost-effective and pollution free, with engines switched off. In this paper Air traffic delay, flight schedule capacity was compared between the U.S and European countries busiest 10 Airports. On analysis, major differences were found in several critical aspects of the utilization of slot system. In general, the use of VFR when weather permits and non-usage of slot constraints makes U.S airport having larger capacity in-terms of aircraft movement. On the other-hand European airports manages air traffic delays using slot system based on the capacity of airport runways and IFR.**

I. INTRODUCTION

Airports have the capacity to safeguard and maintain aircraft. Apart from these, airports provide landing and take-off space, Airports also function with a watchtower to steer air traffic. A smooth and accessible surface for landing and take-off is mandatory. Taxiways (Runway exits) leads to the parking area, aprons and to the gates which comprise of utility buildings namely hangars and terminals. ATC controls the aircraft movement on the ground from arrival to departure, Air traffic between various flight paths of different airlines and operating personnel from respective airlines coordinates functions like aircraft parking ramps and at the passenger gates. Big airports might have air traffic control centres, airport aprons, taxiway bridges, fixed-base operator services, passenger facilities -restaurants and lounges, and emergency services. Assistance from external sources is mostly used for catering, cleaning, refuelling, de-icing and other MRO. Airports facilitate arrival and departure of aircraft. Air traffic controllers assist aircraft as they approach the airport and permit them to land. With this green signal to land, aircraft makes its final landing on to a specified length of land and taxis on to final runway while decelerating. Ground - control is responsible for the directing the aircraft movements on the ground except at runways. From the taxiway to the runway before take-off, aircraft want for instructions. The pilot then guides the aircraft on to a common approach path-15 km in length, generating weak turbulence-which, in turn, must dissipate to allow another aircraft to approach. Dissipation time relies on prevailing environmental conditions and the size and makes of the aircraft. The turbulence rate depends in the size of aircraft.

The separation between aircraft waiting for take-off and in flight is of primary importance. This separation has to be sequential since otherwise, it can affect both take-off and delay. During take-off, wake vortices are formed and another aircraft ready for take-off will be affected by these. Again it is the smaller aircraft that suffers. It is good to maintain minimum separation time, especially for larger aircraft. The best method would be to group the aircraft based on weight and size to reduce larger separation. To safeguard smaller aircrafts minimum aircraft, the minimum separation is required between aircraft to take-off and in flight. The weight of the aircraft plays a crucial role in wake vortices separation. Departure routes and speed of the aircraft also have to be looked into.

Decisions pertaining to gates end related resources needed for smooth running of aircraft and passengers rest with individual airlines. The gate to be used for varied sizes of aircrafts are ruled by physical factors. Keeping in mind reduction of cost, airlines resort to sharing gate facilities. This adversely affects separation and causes traffic snarls, especially in the hangars. Based on separation standard for different aircrafts, the movement of aircrafts in air and in ground is taken care by air-traffic controllers. Active runways for take-offs and landing can be affected by wind shifts. When there is bad weather in an airspace sector or if there is heavy traffic at destination hubs, aircraft ready for departure can be held at the gate or elsewhere. For an airport to operate at its full capacity, the most disturbing factor is the arrival-departure time delay of each aircraft due to various affecting factors such as the headwinds, crosswinds and wake turbulence/wind vortex created by the landing and take-off aircrafts depending on the weather conditions. For most of the busy airports, the above reason could create aircraft delay/even cancelled flight that reduces the airport efficiency.

The two major countries that have made rapid strides in twenty years in air travel are Europe and U.S. In the year 2008, Federal Aviation Administration (FAA) is responsible to study and understand the working of the ATM airport system in the U.S and in Europe. Gulding et al (2008) provides the first report on the above study. Striking difference prevails between the two countries airport like

a) US airports rely on the ATM system for visual separation progress.
b) Airports in Europe limit number of scheduled flights with the help of the slot controls.

Part one provides the background for comparison and discussed some of the features of U.S and European Airport in detail.

Part two shows the arrival-delay comparison depending on the use of separation procedures between the U.S and European Airports. Finally summarizes the conclusion.

II. BACKGROUND:

1) The Airport:

The performance of the airport characteristics shows "Cultural" differences with respect to the operational objectives of the ATM and Airport systems. The difference among 10 Airports with a large number of aircraft flying in 2013 in the U.S and Europe are more concentrated. Figure 1 and Figure 2 shows the list of these airports respectively, and also the traffic catalogue in 2013, which is considered to be the worst year in the aviation history among the airports for airports delays. But also turns out to be the best year for the volume of air traffic. The United States airports are called as "10 leading minus Honolulu"

RANK	CITY	IATA CODE	AIRCRAFT MOVEMENTS	DECLARED CAPACITY (SLOTS/HOUR)
1	PARIS	CDG	552,721	112
2	FRANKFURT	FRA	492,598	83
3	MADRID	MAD	483,848	90
4	LONDON HEATHROW	LHR	481,356	89
5	AMSTERDAM	AMS	454,357	106
6	MUNICH	MUC	431,815	90
7	BARCELONA	BCN	352,489	61
8	ROME	FCO	334,848	88
9	VIENNA	VIE	280,915	66
10	ZURICH	ZRH	268,351	68

Figure 1 Major European Airports

From fig 1 the rightmost column "Declared capacity" indicates the slots available in the airports for aircraft (per hour) in each city. Declared capacity column varies slightly from time to time considering the variation of arrival and departure schedule due to various factors.

RANK	CITY	IATA CODE	AIRCRAFT MOVEMENTS	OPTIMAL CAPACITY	IFR CAPACITY
1	ATLANTA	ATL	980,386	180-188	158-162
2	O'HARE	ORD	927834	190-200	136-144
3	DALLAS	DFW	684779	270-279	186-193
4	LOS ANGELES	LAX	681455	137-148	117-124
5	DENVER	DEN	614169	210-219	159-162
6	LAS VEGAS	LAS	609482	102-113	70-70
7	HOUSTON	IAH	603863	120-143	108-112
8	PHOENIX	PHX	538063	128-150	108-118
9	CHARLOTTE	CLT	522541	130-131	102-110
10	PHILADELPHIA	PHL	498963	104-116	96-98

Figure 2 Major U.S Airports

From Figure 2 the top 2 rightmost column indicates the maximum capacity of movements on the runway per hour considering all weather conditions and Instrumental conditions.

III. VFR AND IFR PROCEDURES

The facilities, systems, and types of equipment used by ATM are more or less advanced compared to both Europe and Unites States. But the ATM used by Europe and the United States vary in some cases and a major difference in the way they are conducted and maintained. The FAA, weather permitting, uses Visual Flight Rules (VFR) for the airport operations, where the pilot of the landing and take-off aircraft is directed by the air traffic control in order to visually maintain risk-free separation distance from the ground and aircrafts on the same runway and other traffic in their immediate vicinity with respect to various factors like weather condition where pilot's physical visibility is required more than that of instrument-based landing aid. In case of weather conditions not permitting the use of VFR, the IFR is used, where ATC is accountable for the separation of the aircraft. European airports use IFR irrespective of the weather conditions. The gain of using VFR is that it results in distances of the landing aircraft, and average recommended distance is less, applied by IFR. So, U.S airports results in larger VFR capacity than the IFR capacity.

IV. IMPACT OF WEATHER CONDITIONS ON AIRPORT OPERATIONS

The meteorological conditions will have a drastic variation impact on the operations of the airport and performance of aircraft. Having considered into account the runway throughput is affected where the separation requirements due to weather condition increase, as the throughput is decreased. The impact of weather like (visibility, convective weather, wind) on operations and on ATM performance can vary

significantly by airport and number of factors like Airport Traffic Management (ATM), Airport equipment (RADAR, IAS (Instrument Approach System), wind conditions and approved rules and procedures.

As it is known that, the movement rate clearly depends on the visibility conditions, the runway throughput reduces, Low visibility procedures (LVP) need to be implemented.

During LVP the separation distance has to be higher for Instrument Landing System (ILS) to maintain the integrity of signal due to which the runway throughput reduces.

The effect of wind condition significant on the runway throughput as the airlines are scheduled based on the distance approach. The large headwind component reduces the ground speed of the aircraft which affects the final approach of the aircraft.

V. MEASURING WEATHER CONDITIONS

Airside airport performances are dependent on weather conditions, as it must be considered when analysing the performance achieved by the airports. In Collaborative Decision Making (CDM) Airports, the analysis of weather is significant to improving the airport airside performances. Both U.S and Europe use Meteorological Terminal Aviation Routine Weather Report (METAR) and impact of weather on aviation performance was evaluated by procedures developed by both the countries. A METAR report consists of data on temperature, intensity, dew point, wind direction and speed, precipitation, visibility and barometric pressure and also provides information on precipitation amount lightning and other pilot needed information like Runway Visual Range(RVR).Earlier, performance analysis indicators classify time period as VMC and IMC, which provides an effect of weather using ceiling and visibility criteria.

Definitions vary between the U.S and European countries, from figure 3, if the visibility is less than 3 miles (5 km) or 1000 ft. IMC conditions are used. VMC (visual meteorological conditions) are used when conditions were better than IMC. There is airport specific intensity where visual approaches are used. Conditions below this magnitude is known as Marginal VMC, i.e., the above values are used to evaluate the various weather conditions frequency.

		Visibility (miles)		
		< 3	[3, 5)	≥ 5
Ceiling (feet)	≥ 3,000	Instrument	Marginal	Visual
	[1000, 3000)	Instrument	Marginal	Marginal
	< 1,000	Instrument	Instrument	Instrument

Figure 3 Ceiling visibility Criteria

Note: VMC does not correspond to good weather condition and there are many weather events like the thunderstorm, rain shower etc. in METAR data records, even during the VMC conditions.

VI. SLOT CONTROL

"Slot control" is used in Europe for flight scheduling i.e., From fig1 the top rightmost column "declared capacity" means count of available slots for unit time, usually per hour the number of movements scheduled is restricted and in airports having elaborate slot controls, other time units (10 minutes,30 minutes) are used occasionally. Airlines operated in the airports acquire right to land depart at a particular time. Theoretically, allotment of the slots available in airports depends on terminal buildings, parking space etc. For major airports, "Declared capacity" is determined by the number of available runways. The Slot Coordinator assigns slots at each airport to airlines on the basis of a set of rules which vary somewhat according to the location of the airport. For example, airports in European Union nations must follow a set of rules promulgated by the European Commission.

VII. DELAY COMPARISON

The effective use of airport infrastructure also impacts a huge difference in services provided by the airport for the users that leads to the efficient use of airport to its capacity and in this paper the services provided to the customers from the airside area is taken into account like the delays and characteristics associated to delay(schedule predictability). For the comparison, the following steps are imparted.

1) Computed the scheduled arrival time of any airline at the gate and the actual arrival time from 10 airports in Part one
2) Impact of weather procedures at U.S Airports is compared.

VIII. IMPACT OF VFR PROCEDURES ON DELAYS IN THE US

Figure 4 the average arrival delay (compared to schedule) at U.S airports for VFR and IFR weather conditions were compared. All flights operated in U.S airports were categorized into two,

1) IFR - "Instrumental Flight Rules" the flight which arrives at the scheduled destination during "Instrumental Meteorological conditions".

2) VFR - "Visual Flight Rules"

The graph plotted used the scheduled arrival time rather than actual arrival time in order to consider the average delay an aircraft makes to reach the destination under all the weather conditions. The Figure 4 shows that the average delay computed for the U.S airports under IFR conditions is higher than the VFR conditions. The average delay relative to schedule time over a time interval of 7 am to 9 pm has considered 10minutes for VFR and 24minutes for IFR flight conditions.

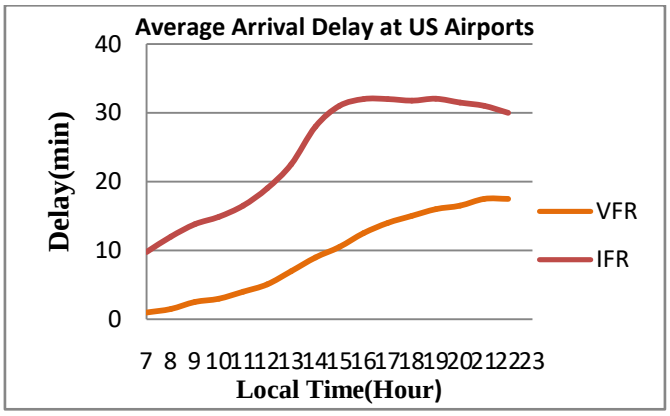

Figure 4 Mean Arrival delay in U.S airport

From Figure 4, Airlines operating in U.S Airports use VFR procedures as a speculative reference point. In case weather conditions not permitting the use of VFR, delay time increases.

Weather conditions vary all-time at Europe and the use of IFR procedures gains more declared capacity rates compared to U.S Airports and comparison shows that the European Airports with respect to Air traffic delay compared to weather conditions is less dependent than U.S airports. Due to lack of data from the CODA database, it is very difficult to compete for European airports and to perform a comparison under the VFR and IFR conditions.

IX. AVERAGE DELAY COMPARISON

Comparison of Average delay time on a typical day at the major airports under all weather conditions. The time window selected for this approach is the local time of Airport operations, i.e. in figure 5 Average delay time of flights to arrive at the 10 airports between 7 am to 10 pm times period is compared.

Note: The data for European airports are unevenly distributed and non-representative after the local hour 9 pm as they are unevenly distributed among the airlines and airports and it is very difficult to analyse. So, the data is limited to 9 pm.

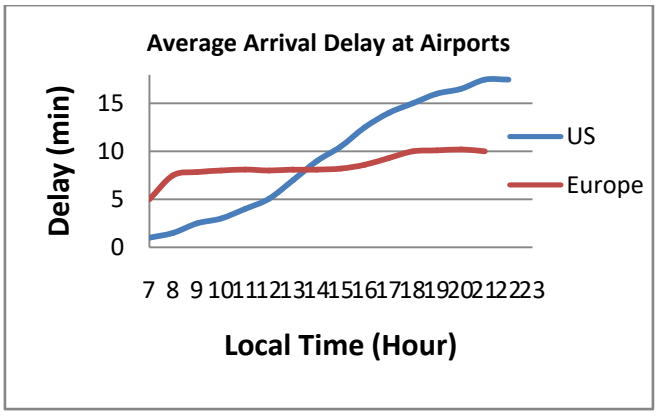

Figure 5 Mean Arrival delay at U.S and Europe airports

Figure 5 shows the evolution of flight delays per day over a time period where the delay time pitches up from minimum delay to maximum at 9 pm, as the day progresses in U.S airports i.e., The average delay during early and late night hours are minimum and rises during the peak hours from 10 am to 10 pm. and the European airports, by contrast, manages to sustain a constant arrival delay relative to schedule and after 2pm, twice the level of delay at the U.S Airports. From, the graph, it is concluded that the European Airports manages the Flight schedule in a more sustainable and uses the airport capacity to the threshold level than at the U.S Airports resulting in delays that are significantly more reasonable. The "Slot control" system utilizes IMC in preventing the Air-Traffic and build-up of queues in European Airports as the day progresses.

X. CONCLUSION

In the US, the Air Traffic Control System Command Centre - which is the equivalent of Network Manager Operations Centre in Europe, is in a stronger position than its European counterpart with the more active involvement of tactically managing the arrival-delay using the slot system on the day of operations.

Based on scheduled limitations the U.S Airports operates with better utilization of airport capacity and efficiency even during ideal weather conditions. Europe on other hand utilizes IFR weather procedures and operates with higher declared capacity. Airports in the U.S having more than 3 runways shows higher declared capacity rates and for Europe, airports like CDG, FRA, LHR has declared characteristics equivalent to U.S airports.

The European and U.S major airport network and related ATM systems utilize the equipment and all advanced technologies in a similar manner and the significant difference exists in scheduling practices and operating procedures that might reflect the existing difference approaches to the management of air transport. Thus, the performance of major airports in both the countries differs in significant ways, with neither the system performing better than the other in every aspect. Our summary finding is that the comparison between the US and European major airports represent the uses VFR and IFR weather procedures based on which air traffic delay and scheduled flight capacity were overblown.

Airline service Delay:

In 2013, flights arrived on the average delay time of 10 minutes in VFR weather and 24 minutes in IFR weather. The use of VFR all the time irrespective of weather conditions less than the normal by the U.S airports makes them more linear towards excessive delays and the use of VFR requires over-scheduling of flights as the flight could not reach the gate on scheduled time. Thus, the performance and the airport efficiency decline gradually. By the use of IFR procedures by

the European airports make them sustain over a less variable performance with respect to weather conditions.

From the figure 4, we can also visualize that from local time 3 pm to 10 pm, the average delay increases steadily in VFR weather. Due to this condition, unsustainable flight delay conditions occur. When considered the European Airport, manages to prevail persistent average delay time for most of the delay i.e., use of slot system is effective in preventing airports from demands. In U.S arrival time uncertainty prevails throughout the day and in contrast, the European airports are differentiated by in a number of ways even when delay increases, the average delay distribution becomes concentrated.

Therefore from the study of delay performance between the U.S and European airports, depending on weather conditions, instrumental navigation and ATM procedures both the airports use the resources efficiently with difference in their airport performance, focusing on delay comparison the use of VFR and IFR procedures depends on the prevailing weather conditions and European airports manages flight scheduling depending upon the slot system makes more sustainable and reliable. In contrast, U.S airports having VFR procedural constraints making them more vulnerable to Flight delays. Declared capacities if determined properly, makes airport maintain demands and thus provide satisfactory service even under delay conditions.

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