Information on airport capacity and delay is important to the airport planner. There is a strong belief within the aviation community that significant gains in air transportation efficiency can be realized through an understanding of the factors causing delays and by the application of technological innovations and operational policies to alleviate delay.
The term capacity is used to designate the processing capability of a service facility over some period of time, typically defined as the maximum number of operations that a service facility can accommodate over a defined period of time.
Capacity and Delay

In the field of aviation, levels of demand that exceed the capacity at a given component of an airport or airspace result in system delays, where delay may be defined as the increase in time required to perform an operation from “normal” nondelayed operations. Additional time required may come in the form of queuing, or waiting, to perform an operation, or a reduction in speed due to congestion.
An operation on the airfield is often defined as a takeoff or a landing, while in the terminal an operation may be the processing of a passenger through the terminal. In the airspace, an operation may be considered an aircraft traveling through a certain sector of airspace.
the primary objective of capacity and delay studies is to determine effective and efficient means to increase capacity and reduce delay at airports, analyses are conducted to examine the implications of the changes in the nature of the demand, the operating configurations of the airfield and the impact of facility modifications on the quality of service afforded this demand.
Some of the typical applications of these analyses might include:

1. The effect of alternative runway exit locations and geometry on runway system capacity

2. The impact of airfield restrictions due to noise abatement procedures, limited runway capacity, or inadequate airport navigational aids on aircraft processing rates

3. The consequences of introducing new aircraft into the fleet mix at an airport, and an examination of alternative mechanisms for servicing the mix

4. The investigation of alternative runway-use configurations on the ability to process aircraft

5. The generation of alternatives for new runway or taxiway construction to facilitate aircraft processing

6. The gains which might be realized in system capacity or delay reduction by the diversion of general aviation aircraft to reliever facilities in large air traffic hub areas
Capacity and Delay

Source: DOT.

Note: Total may not add up to 100 percent due to rounding.

Figure 12-2 DOT reported sources of delay, United States, 2007.
The Number of A/C operation during a specific interval of time corresponding to acceptable level of average delay

**Figure 12-3** Delay as a function of capacity and demand.
Factors That Affect Airfield Capacity

1. The configuration, number, spacing, and orientation of the runway system
2. The configuration, number, and location of taxiways and runway exits
3. The arrangement, size, and number of gates in the apron area
4. The runway occupancy time for arriving and departing aircraft
5. The size and mix of aircraft using the facilities
6. Weather, particularly visibility and ceiling, since air traffic rules in good weather are different than in poor weather
7. Wind conditions which may preclude the use of all available runways by all aircraft
Factors That Affect Airfield Capacity Cont.

8. Noise abatement procedures which may limit the type and timing of operations on the available runways

9. Within the constraints of wind and noise abatement, the strategy which air traffic controllers choose to operate the runway system

10. The number of arrivals relative to the number of departures

11. The number and frequency of touch and go operations by general aviation aircraft

12. The existence and frequency of occurrence of wake vortices which require greater separations when a light aircraft follows a heavy aircraft than when a heavy follows a light aircraft

13. The existence and nature of navigational aids

14. The availability and structure of airspace for establishing arrival and departure routes

15. The nature and extent of the air traffic control facilities
Runway Capacity

For runways used exclusively for arrivals or departures the model was that of a simple Poisson type queue with a first come, first served service discipline. The demand process for arrivals or departures was characterized as a Poisson distribution with a specified mean arrival or departure rate.

For mixed operations, when runways are used for both takeoffs and landings, the process is more complicated, and a preemptive spaced arrivals model was developed. In this model, arrivals have priority over departures for the use of the runways.
Mathematical Formulation of Delay

Exclusively for arrivals

\[ W_a = \frac{\lambda_a \left( \sigma_a^2 + 1/\mu_a^2 \right)}{2(1-\lambda_a/\mu_a)} \] (12-1)

where \( W_a \) = mean delay to arriving aircraft
\( \lambda_a \) = mean arrival rate of aircraft
\( \mu_a \) = mean service rate for arrivals or the reciprocal of the mean service time
\( \sigma_a \) = standard deviation of the mean service time of the arriving aircraft
Mathematical Formulation of Delay

Exclusively for Departure

\[ W_d = \frac{\lambda_d \left( \sigma_d^2 + 1/\mu_d^2 \right)}{2(1 - \lambda_d/\mu_d)} \]  

(12-2)

where 
- \( W_d \) = mean delay to departing aircraft
- \( \lambda_d \) = mean departure rate of aircraft
- \( \mu_d \) = mean service rate for departures, or the reciprocal of the mean service time for departures
- \( \sigma_d \) = standard deviation of the mean service time of the departing aircraft
Mathematical Formulation of Delay

For Mix Operation

\[ W_d = \frac{\lambda_a (\sigma_j^2 + j^2)}{2(1 - \lambda_d^j)} + \frac{g (\sigma_f^2 + f^2)}{2(1 - \lambda_d^f)} \]  \hspace{1cm} (12-3)

where  
\( W_d \) = mean delay to departing aircraft  
\( \lambda_a \) = mean arrival rate of aircraft  
\( \lambda_d \) = mean departure rate of aircraft  
\( j \) = mean interval of time between two successive departures  
\( \sigma_j \) = standard deviation of the mean interval of time between successive departures  
\( g \) = mean rate at which gaps between successive arrivals occur  
\( f \) = mean value of the interval of time within which no departure can be released  
\( \sigma_f \) = standard deviation of the interval of time in which no departure may be released
Mathematical Formulation of Delay

Example for Arrival only

compute the average delay to arriving aircraft on a runway system which services only arrivals if the mean service time is 60 s per aircraft with a standard deviation in the mean service time of 12 s and the average rate of arrivals is 45 aircraft per hour.

\[ W_a = \frac{\lambda_a (\sigma_a^2 + 1/\mu_a^2)}{2(1 - \lambda_a/\mu_a)} \]

\[ W_a = \frac{45\left[(12/3600)^2 + 1/60^2\right]}{2\left(1 - \frac{45}{60}\right)} = 0.026 \text{ h} = 1.6 \text{ min} \]
Runway Capacity Using Time-Space Concept

The basic sequencing rules:

1. Two aircraft may not conduct an operation on the runway at the same time.

2. Arriving aircraft have a priority in the use of the runway over departing aircraft.

3. Departures may be released if the runway is clear and the subsequent arrival is at least a certain distance from the runway threshold.
Runway Capacity Using Time-Space Concept

Figure 12-4 Time-space diagram concepts for mixed operations on runway system.
My Dear Friends
I Really Enjoyed Sharing Knowledge with You all

Thank You & I Wish You the Best of Luck

May Allah, Al-Mighty, Grant you Righteousness and Success