

## Runway System Capacity

Learning objectives:

- Active runways
- Runway configuration
- Independent runways
- Dependent runways
- Independent runways
- Staggered runway thresholds & Near-end/Far-end runway thresholds
- Closely spaced parallel runways
- Medium spaced parallel runways
- Impact of wind direction and magnitude on runway capacity
- Impact of runway geometry on runway capacity
- Impact of noise on runway capacity
- Intersection, Converging, Diverging runways

Acronyms used in this unit:

|      |   |
|------|---|
| ATM  | Air Traffic Management System             |
| IFR  | Instrument Flight Rules                   |
| MTOW | Maximum certified Takeoff Weight          |
| FAA  | Federal Aviation Administration           |
| PRM  | Precision Runway Monitor System           |
| ICAO | International Civil Aviation Organization |

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## Capacity of Runway Systems

The capacity of a system of runways is determined by the capacity of the individual runways that area available for simultaneous use. The previous chapter described methods for computing the theoretic maximum throughput capacity (MTC) for the individual runways. This chapter describes how the capacity for a system of runways is determined.

The capacity of multiple runway systems is determined by the number of runways available for simultaneous use.

- (1) wind direction and magnitude
- (2) independence of runways
- (3) Noise and/or environmental constraints

## Wind Direction and Magnitude

Winds are the primary determinant of the number of runways available for simultaneous use. Aircraft can use a runway for takeoff or landing only when the crosswinds are within prescribed limits and tailwinds does not exceed 5 – 6 knots (9-11 km/h). The prescribed limits for crosswinds are summarized in the table below:

| Aircraft Type                          | Maximum Crosswind Allowed |
|--|---------------------------|
| Reference field length < 1200m         | 10.5 knots                |
| 1200m > reference field length > 1499m | 13 knots                  |
|  | 16 knots                  |
| Reference field length > 1500m         | 20 knots                  |

At airports that experience frequent periods of sustained strong winds from several different directions, the number of runways aligned with the wind direction to meet an availability of 95% can be high. In contrast, several major airports operate with an availability in excess of 95% with single direction runways. Figure 1-a shows the runway configurations for Chicago Midway that requires runways that run north-west/south-east and north-east/south-west to provide crosswind coverage in all the prevailing wind directions at that location. Figure 1-b shows the runway configurations for Orlando that require only north/south runways to provide crosswind coverage for the prevailing winds in the region.

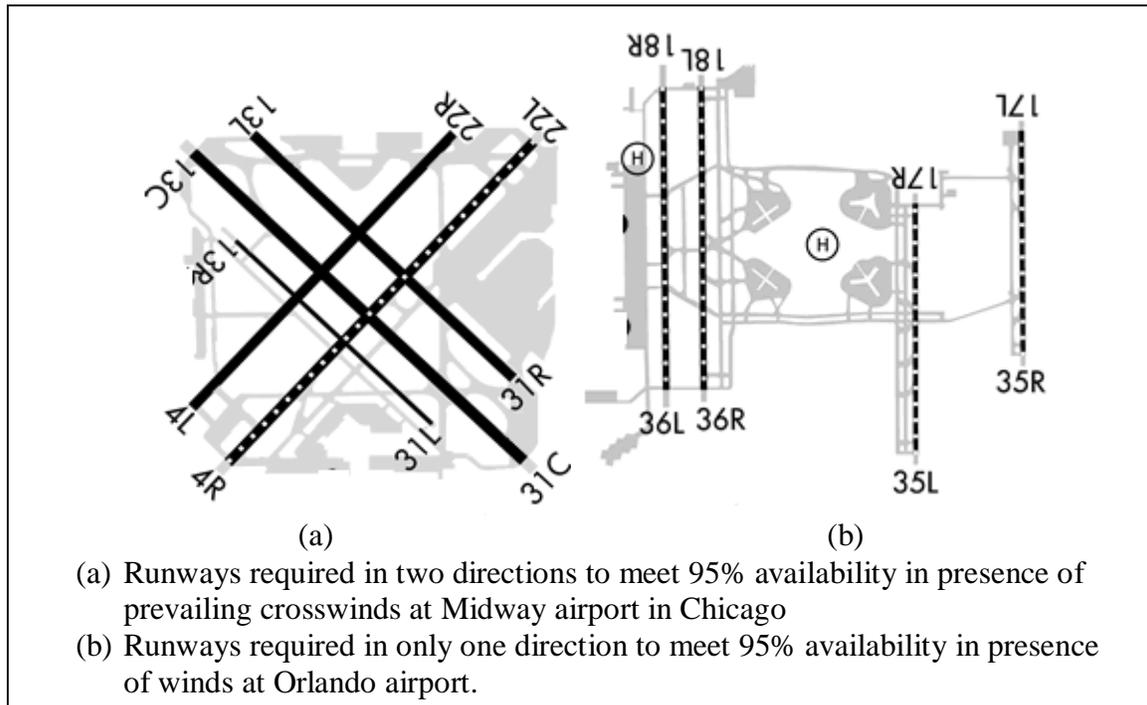


Figure 1. Example of Runway Configurations

The capacity of a runway system is primarily determined by the number of runways available for use at any given time and. This is known as the runway configuration and is determined by wind direction and magnitude, the geometry of the runways and noise/environmental considerations.

## Independence of Runways

In addition to the number of active runways, the capacity of the runway system is also determined by the independence of the available runways. Independent runways operate without restrictions. Dependent runways operate with restrictions determined by the type of operations on adjacent runways.

There are two type of dependence: (1) parallel runway dependence, and (2) intersection runway dependence.

## Dependence and Independence of Parallel Runways

Parallel runways are a common geometric configuration used at major airports. By duplicating the number of runways in a given direction, the capacity of the runway system is increased when prevailing wind require use of these runways.

Operations on parallel runways can be grouped into three categories: (i) dependent close parallel runway operations, (ii) dependent medium spaced parallel runway operations, and (iii) independent parallel runway operations.

The degree of dependence for mixed arrival/departure operations for parallel runways is summarized in Table 1.

For close parallel runways, when the runways are used exclusively for arrivals or exclusively for departures, they must operate *as dependent runways* and the separation rules for single runway operation apply. For example, for arrivals, sequential aircraft landing on each runway must have the same separation requirement as if they were landing on the same runway.

When close parallel runways are used for departures and arrivals, they must operate as *dependent runways* and the single runway rule applies. The landing aircraft must be at least 2nm from the departure runway when the departure begins and may not touchdown before the departure has left the runway. One small variant is that a departing aircraft does not have to wait until the landing aircraft has cleared the adjacent parallel runway before initiating the departure roll.

| <i>Separation between runway centerlines</i> | <i>Arrival /Arrival</i>                          | <i>Departure /Departure (Note 2)</i> | <i>Arrival/ Departure</i> | <i>Departure/ Arrival</i> |
|--|--|--------------------------------------|---------------------------|---------------------------|
| <b>Up to 2500ft (up to 762 m)</b>            | Parallel runways operate as single runway        |                                      |                           |                           |
| <b>2500-4300ft (762-1310 m)</b>              | 1.5 nm diagonal distance between lead and follow |                                      | Independent               | Note 1                    |
| <b>4300 ft or more (1310 m or more)</b>      |  |                                      | Independent               |                           |

TABLE 1 TYPE OF OPERATION PERMITTED IN PARALLEL RUNWAYS AND THE IMPACT ON CAPACITY

- 1- Departing flight does not have to wait for arriving flight to clear the adjacent parallel runway.
- 2- Assumes diverging climb paths.

When medium parallel runways are used for arrivals exclusively, the landing and trailing aircraft must be staggered (see Figure 1). The trailing aircraft must be 1.5nm behind the leading aircraft. The 1.5nm distance is measured diagonally between the two aircraft and can impose an additional separation distance two aircraft landing on the same runway.

When medium parallel runways are used exclusively for departures they operate as independent runways. Departures can operate simultaneously.

When one medium parallel runway is used for arrivals only and the other for departure only, the runways can also operate independently.

When parallel runways are more than 4300 ft apart, the runway can be operated independently. In some cases, the FAA has authorized the use of parallel runways spaced 3400 ft apart to operate as independent runways when the Air Traffic Controllers have use of the Precision Runway Monitor (PRM) system. The PRM provides improved accuracy radar surveillance data to the controllers to ensure safe separation.

The discussion above is based on the assumption that the parallel runway thresholds are aligned. When the runways are staggered such that the runway thresholds are offset, then the “effective separation distance” between runway centerlines is adjusted. For example, when arrivals are to the “near end” runway and departures on the “far end” runway, the 2500 ft separation requirement is reduced by 100 ft for each 500 ft of threshold offset down to a minimum of separation distance of 1200 ft. For example, when a runway offset is 1000ft, a separation of 2300 ft between runway centerlines is equivalent to a 2500 ft separation distance. When departures are to the near end and arrivals to the far end, the separation distance is reduced.

## **Intersecting, Converging, or Diverging Runways**

Intersecting runways are constructed to support multiple prevailing wind directions using restricted real-estate. Runways are considered to intersect when their tarmac crosses each other. Runways converge or diverge when the projections of their centerlines converge or diverge.

The rules that affect capacity vary from airport to airport and from country to country for intersecting, converging and diverging runways and are too variable to generalize in this text, but some basic principles apply.

Figure 1 shows the runway configuration at LaGuardia airport. There are two runways that intersect at right angles. Runways 4/22 runs north-east/south-west, and runways 13/31 runs south-east/north-west. The airport tries to operate using one runway dedicated to arrivals and the other runway dedicated to departures. In this way, as soon as an arrival crosses the intersection, the departure is free to use the crossing runway. The runway system capacity is maximized when runway 22 is used for arrivals, and runway 13 is used for departures. In this configuration, departing aircraft have to wait for arriving aircraft to traverse the shortest distance to the intersection before the departure runway is available. In other configurations (e.g. 4/31) flights have to wait longer before the flights cross the intersection.

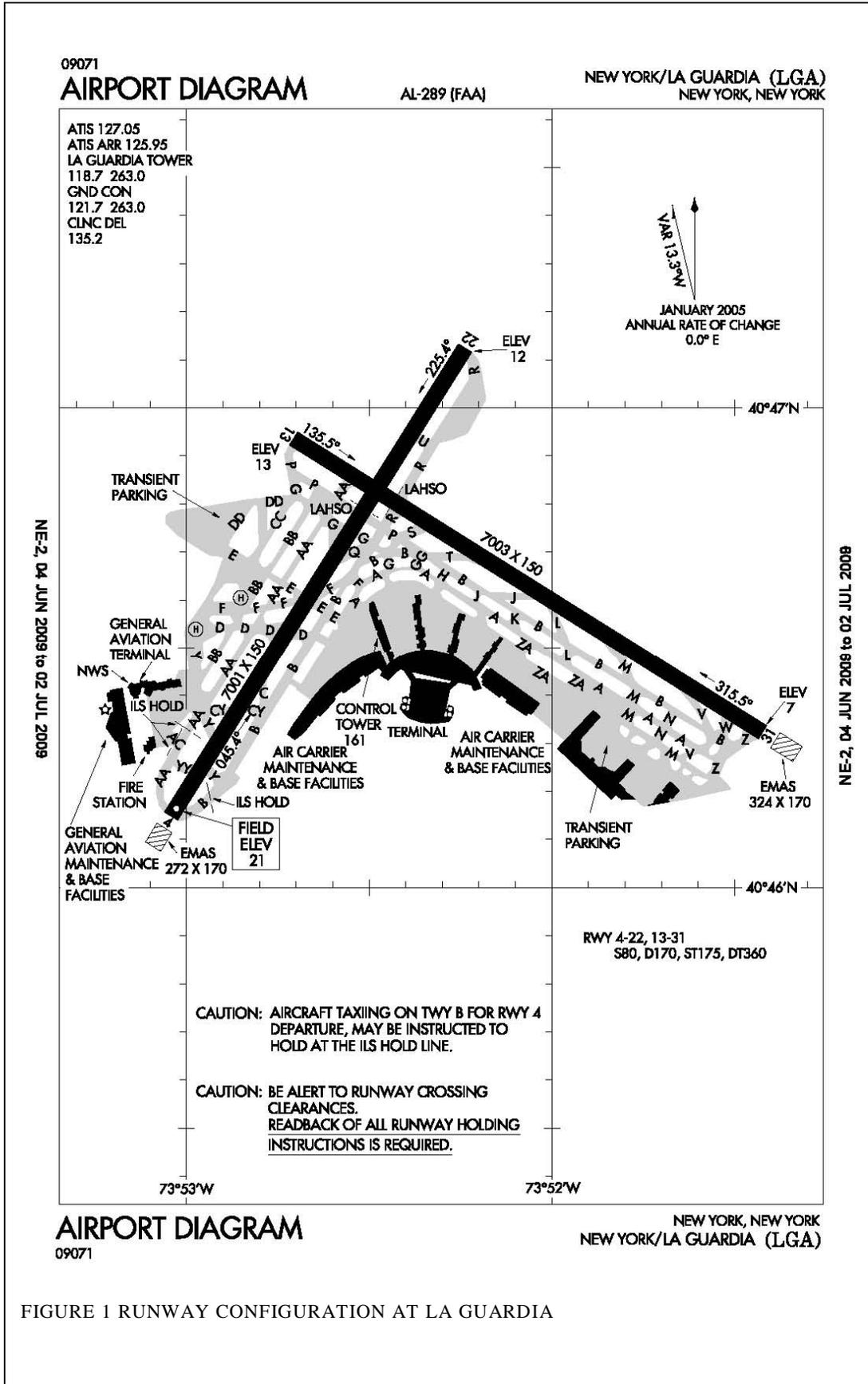


FIGURE 1 RUNWAY CONFIGURATION AT LA GUARDIA

## Noise Considerations

Environmental considerations, especially noise has an important influence in determining runway system capacity. Air traffic controllers choose runway configurations to minimize noise over populated regions. For example, at Los Angeles airport, shown in Figure 2, assuming wind conditions are calm and operations can occur from either end of the runway, ATC can choose to operate the runways by landing from the east and departing towards the ocean (west). In this way, the population to the east of the airport is subject to the idle thrust noise from descending aircraft, and not the Maximum takeoff thrust required for departures.



FIGURE 2 VIEW OF LOS ANGELES AIRPORT

There are three types of noise-related restrictions and configurations are usually due to:

- Noise mitigation for densely populated areas
- Short-term and long-term goals for runway utilization. The objective is to distribute noise among neighboring communities in a way that is considered fair by the parties involved.
- Minimize continuous exposure of any single community to noise on any particular day. For example, in Boston/Logan no runway can be used continually for more than 4 h in any single direction and no runway can be used for more than 24 h in any 72-h period.

## Test your knowledge!

Download the airport diagrams for MDW, STL, and MCO

- 1- Review airport diagrams to identify the prevailing wind directions at PHX, ATL, SEA, ORD. Explain how this conclusion was reached.
- 2- MDW has two runway configurations. Does either runway configuration at MDW generate more capacity. Explain.
- 3- Do the rules for simultaneous runway use affect the Maximum throughput capacity for MDW. Explain.
- 4- Which runway system has greater capacity St Louis (STL) or Orlando (MCO) explain.
- 5- Which runway system has greater capacity. Explain.
  - (a) Airport A and B have two parallel runways. The runway thresholds are aligned. Airport A parallel runways are 2000 ft apart. Airport B parallel runways are 4000 ft apart.
  - (b) Airport A and B have two parallel runways. The runway thresholds are staggered by 1000ft. Airport A parallel runways are 2000 ft apart. Airport B parallel runways are 4000 ft apart.