*Chapter Three:*

# Capacity Analysis

# CHAPTER THREE: CAPACITY ANALYSIS

In this chapter the capacity of the Renton Municipal Airport is examined. From this analysis, the capacity of the airport's facilities to serve forecast levels of demand can be determined. By analyzing the relationship between demand and capacity, deficiencies in the system can be identified and steps toward alleviating them can be studied. Three major components of the airport were examined:

- Airfield;
- Terminal Area; and
- General Aviation Area.

The analytical techniques, input data, and results of these examinations are detailed throughout this section.

## 3.1 AIRFIELD CAPACITY

The capacity of the airfield is a measure of the theoretical maximum number of aircraft operations that can be accommodated on the airfield, or its components, over a specified period of time. A variety of techniques have been developed for determining this airfield capacity. Currently, the most widely accepted technique is described in FAA Advisory Circular 150/5060-1. The analyses employed herein are based upon this publication and its associated computer modeling techniques.

Utilizing the methodology presented in the FAA document produces statements of airfield capacity in these major terms:

- Hourly Capacity of Runways: The number of aircraft operations that can take place on the runway system in one hour; and

- Annual Service Volume (ASV): A reasonable estimate of the airport's annual capacity. The ASV accounts for differences in runway use, aircraft mix, weather conditions, and other limiting factors that can occur over a year's time.

Following the determination of the airfield capacity, computational techniques are available by which the total annual delay to both arriving and departing aircraft can be estimated.

### 3.1.1 Runway Capacity

The capacity of a runway system is determined by several factors. Among these are meteorology, runway use patterns, aircraft mix, percent of operations that are arrivals, percent of operations that are touch-and-goes, the spacing of exit taxiways, and runway length.

Each of these elements, and its impact on the runway capacity of Renton Municipal Airport, are discussed in the following paragraphs.

Meteorology

Weather conditions at an airport affect runway utilization due variations in wind direction and velocity, together with changes in visibility. The prevailing wind and visibility conditions serve to determine the directions in which takeoffs and landings may be conducted, and the frequency of use for each available operating configuration. Since various airport operational configurations have different capacities, it is necessary to identify each potential configuration, calculate its capacity, and determine the percentage of the time it is likely to be in use.

The terms visual meteorological conditions (VMC) and instrument meteorological conditions (IMC) are used as measures of ceiling and visibility. VMC conditions occur when the ceiling is at least 1,000 feet and visibility is three miles or greater. During these conditions pilots can elect to fly under visual flight rules (VFR) on a see-and-be-seen basis and visual approaches can be conducted independently on parallel runways that are at least 700 feet apart. IMC conditions occur when the ceiling is less than 1,000 feet or visibility drops below three miles. In IMC weather, pilots must fly under instrument flight rules (IFR) and the air traffic control (ATC) system assumes sole responsibility for the safe separation between aircraft. Parallel runways separated by less than 2,500 feet are seen as a single runway with operations on one completely dependent on operations on the other.

The method of analyzing meteorological conditions related to ceiling, visibility, and runway orientation involves the use of wind roses. Wind data for all weather, VMC, and IMC conditions are represented on the wind roses in terms of the percentage of time winds of different velocities blow from various directions. Data for conducting weather and wind analysis for the Renton Municipal Airport were obtained from the National Oceanic and Atmospheric Administration's (NOAA), National Climatic Center (NCC) in Asheville, North Carolina. The FAA's Airport Design for Microcomputers Version 3.0 was used to perform the analysis.

Exhibit 3-1 tabulates the weather categories and wind coverage for individual and combinations of runways.

## EXHIBIT 3-1: WIND COVERAGE OF EXISTING RUNWAYS

| Weather Category | Max. Cross. Component | Occurrence | Runway Coverage | | |
|---|---|---|---|---|---|
| | | | 15 | 33 | 15-33 Combined |
| All Weather | 10.5 knots | 100% | 92.5% | 3.9%[1] | 96.4% |
| | 13.0 knots | | 94.3% | 4.2%[1] | 98.5% |
| VMC | 10.5 knots | 87.3% | 91.9% | 4.2%[2] | 96.1% |
| | 13 knots | | 94.1% | 4.6%[2] | 98.7% |
| IMC | 10.5 knots | 12.7% | 94.8% | 2.2%[3] | 97.0% |
| | 13 knots | | 95.6% | 2.2%[3] | 97.8% |

[1] Runway end wind coverage includes 0-3 mph "calms" that occur 83.1 percent of the time.
[2] Runway end wind coverage includes 0-3 mph "calms" that occur 81.5 percent of the time.
[3] Runway end wind coverage includes 0-3 mph "calms" that occur 86.1 percent of the time.

The following observations were made from the analyses of wind data:

- Visual meteorological conditions (VMC) occur 87.3 percent of the year;
- Instrument Meteorological Conditions (IMC) occur 12.7 percent of the year;
- The combined coverage of the existing runways is 96.1 percent in VMC and 97 percent in IMC using a 10.5 knot crosswind component; and
- The combined coverage of the existing runways is 98.7 percent in a VMC environment and 97.8 percent in IMC using a 13 knot crosswind component.

<u>Terminal Area Navigational Aids</u>

The availability, types, and location of navigational aids on and in the vicinity of an airport affect the capacity of the facility in both visual and meteorological weather conditions. For instance, multiple instrument runways increase the number of operational configurations available during IMC conditions and, therefore permit greater flexibility in selecting capacity efficient configurations under a variety of weather conditions.

The navigational aids available at Renton Municipal Airport were described in Chapter 1. The runway ends available for IMC operation were defined in terms of the published approaches associated with these facilities. The IMC operating configurations were then selected on the basis of this information, with a nonprecision instrument approach available to Runway 15, while a visual approach is available to Runway 33.

Runway Usage

Runway use is expressed in terms of the number, location, and orientation of active runways. It involves the directions and kinds of aircraft operations using each runway. During periods of high wind, operations are conducted on the runway providing the highest wind coverage. Therefore, the operational configurations for the capacity analysis are determined by wind conditions.

Operational Fleet Mix

The mix of the aircraft fleet using, or expected to use, the Renton Municipal Airport is another important factor in determining the capacity of the airfield. A homogeneous fleet would result in higher airfield capacity due to evenly spaced approaching and departing aircraft. As the mix between large and small aircraft increases, the need for broader spacing to avoid wake vortices occurs. Additionally, the seaplanes that land in Lake Washington from the south impact the airfield because they occupy airspace above the runway.

The analysis of airfield capacity requires that total annual operations be presented according to aircraft classification categories. Forecasts of annual operations were developed for each planning period and presented in Chapter 2. Further, the aircraft fleet mixes were also determined.

The next step required that the forecast of operations data be translated into a classification system compatible with the airfield capacity methodology. The capacity and delay model used for the Renton Municipal Airport defines the aircraft fleet mix in terms of four classes, as presented in Exhibit 3-2. Using the fleet mix forecasts from Chapter 2 together with the data from this exhibit, the annual operations forecast by aircraft classification were prepared and are shown in Exhibit 3-3 and 3-4.

## EXHIBIT 3-2: OPERATIONAL FLEET MIX CLASSIFICATION SYSTEM

**Category A: Small single-engine, gross weight 12,500 pounds or less.**

| | | |
|---|---|---|
| Examples: | Cessna 172/182<br>Beech Bonanza | Mooney 201<br>Piper Cherokee/Warrior |

**Category B: Small twin-engine, gross weight 12,500 pounds or less.**

| | | |
|---|---|---|
| Examples: | Beech Baron<br>Cessna 402<br>Cessna Citation<br>Beech 99 | Mitsubishi MU-2<br>Piper Navajo<br>Rockwell Shrike<br>Lear 25 |

**Category C: Medium multi-engine, gross weight 12,500 to 300,000 pounds.**

Examples:

| | | |
|---|---|---|
| General: | Beech King Air 200<br>DeHavilland DH-7<br>Swearingen Metro<br>Embraer Bandeirante | Fairchild FH-227<br>Gulfstream III<br>Lear 35/55 |
| Stage II:<br>(2-3 engine) | Boeing 727-100 and 200<br>Boeing 737-100 and 200<br>McDonnell Douglas DC-9, DC-9-30, DC-9-50<br>Fairchild F-28 | |
| Stage III:<br>(2-3 engine) | Boeing 737-300, 737-400, 737-500,757<br>McDonnell Douglas MD80 | |
| Stage III:<br>(4 engine) | British Aircraft BAe 146 | |

**Category D: Large aircraft, gross weight more than 300,000 pounds.**

Examples:

| | |
|---|---|
| Stage II:<br>4 engine narrow-body<br>3-4 engine wide-body | McDonnell Douglas DC-8 (Hushkit)<br>Boeing 707 (Hushkit)<br>Boeing 747-100, 747-200 |
| Stage III:<br>2 engine wide-body | Boeing 767<br>Airbus Industrie |
| 3-4 engine wide-body | Lockheed L-1011<br>Boeing 747-200, 747-300, 747-400<br>McDonnell Douglas DC-10-40, DC-10-10, DC-10-30 |
| 4 engine narrow-body | McDonnell Douglas DC-8-70 |

Source: BWR Airport Division

**EXHIBIT 3-3: OPERATIONAL FLEET MIX - VMC CONDITIONS**

| Aircraft Classification | 1993 | 1998 | 2003 | 2013 |
|---|---|---|---|---|
| A | 91.0% | 88.6% | 87.8% | 86.9% |
| B | 9.0% | 11.4% | 12.2% | 13.1% |
| C | 0% | 0% | 0% | 0% |
| D | 0% | 0% | 0% | 0% |
| Total | 100% | 100% | 100% | 100% |

Under IMC conditions this fleet mix will be slightly different due to the limitations of the aircraft operating. Smaller aircraft and discretionary flyers are not generally equipped to, or choose not to, operate under these conditions. Therefore the percentage of B, C, and D aircraft usually will be higher. Exhibit 3-5 presents the IMC fleet mix. As can be noted in these exhibits, no C and D aircraft are identified as part of the fleet mix for the purpose of the capacity calculations. The reason for this is the unique nature of the Boeing 737 and 757 operations. Boeing 737s and 757s do not operate in the regular flow of traffic utilizing the airport. Rather, as explained in Chapters 1 and 2, the limited amount of Boeing 737 and 757 activity involves predetermined departures only that can be scheduled for periods of low traffic.

**EXHIBIT 3-4: OPERATIONAL FLEET MIX - IMC CONDITIONS**

| Aircraft Classification | 1993 | 1998 | 2003 | 2013 |
|---|---|---|---|---|
| A | 78.5 % | 77.8 % | 82.5 % | 86.8 % |
| B | 21.5 % | 22.2 % | 17.5 % | 13.2 % |
| C | 0 % | 0 % | 0 % | 0 % |
| D | 0 % | 0 % | 0 % | 0 % |
| Total | 100% | 100% | 100% | 100% |

<u>Percent Arrivals</u>

The percentage of all aircraft operations that are arrivals has an influence on the capacity of runway configurations. For example, a runway used exclusively for departures will have a different capacity than one used solely for arrivals, and either case will exceed the capacity of a runway used for both arrivals and departures. At the Renton Municipal Airport, both runway ends are used for arriving and departing aircraft. It is assumed that arrivals and departures each constitute 50 percent of total annual and peak period operations.

Touch-and-Go Operations

A touch-and-go operation refers to an aircraft landing and then making an immediate takeoff without coming to a full stop. These operations are normally associated with training and are important contributors to airport operational activity. Because of their continuous motion, touch-and-go operations do not occupy a runway for very long, and therefore a high percentage of touch-and-go activity yields a relatively high airfield capacity. Touch-and-go activity was determined to be approximately 40 percent of total operations.

Exit Taxiways

An important physical characteristic considered in the airside capacity analysis is the number and type of taxiways available to exit the runway. The location of exit taxiways affects the occupancy time of the runway. The longer a plane remains on the runway, the lower the capacity of that runway. However, at Renton, since the small aircraft do not operate for long periods of time with a constant landing and departure stream and the separations are minimal, the high speed exits do not change the capacity at the airport. The existing facilities map in Chapter 1 identified the location of the exit taxiways on the airport. These will be used in the capacity calculations.

### 3.1.2 Analysis of Capacity and Delay

The results of the capacity and delay analysis provide estimates of hourly airfield capacity and aircraft delay. Hourly airfield capacity is defined as the maximum number of aircraft operations that can take place on the airfield in one hour.

Delay to aircraft is defined as the difference between the actual time it takes an aircraft to operate on the airfield and the normal time it would take the aircraft to operate without interference from any other aircraft using the airspace or airfield. Therefore, the delay refers to the time spent waiting to land or take off caused by other aircraft.

Hourly Capacity of the Runway System

Hourly runway capacities were calculated under VMC and IMC conditions for the years 1993, 1998, 2003, and 2013. Exhibit 3-5 shows the results of the hourly capacity analysis for the airport.

**EXHIBIT 3-5: HOURLY DEMAND/CAPACITY SUMMARY**

| Year | VMC Demand | VMC Capacity | IMC Demand | IMC Capacity |
|---|---|---|---|---|
| 1993 | 41 | 128 | 1 | 61 |
| 1998 | 53 | 128 | 2 | 61 |
| 2003 | 55 | 128 | 2 | 61 |
| 2013 | 59 | 128 | 2 | 61 |

As demonstrated in the exhibit, hourly capacity is not exceeded during the planning period.

Annual Service Volume

The hourly capacity figures cited in the previous section are representative of the number of operations that can occur during a specific time period. It is unreasonable to assume that this peak saturation level could be maintained over a long period of time without a breakdown in the system. To account for this fact, another measure of capacity called the Annual Service Volume (ASV) is used. The ASV is not a measure of saturation but rather of service. This measurement uses the following criteria in its calculation.

- As annual demand approaches the ASV, delay to aircraft starts to increase rapidly;
- When annual demand equals ASV, a reasonable level of service exists for much of the year; and
- When annual demand is 20 percent higher than annual service volume, the airport will experience severe congestion.

Annual service volume is used as a planning guide to determine the need for new facilities. Is also useful as a measure of the level of annual demand that can be expected to occur at an airport with marginal capacity available.

Annual service volume is a function of the weighted hourly capacity of the airfield and its peaking characteristics. The calculation of ASV combines the hourly capacity of each operational configuration and the percentage of time that each configuration is in use with the ratio of design day operations to peak month operations and design hour operations to design day operations. If the airport has very low peak period demands, as expressed by peak month, design day, and design hour operations, it will have a higher ASV. If the airport experiences periods of great demand followed by periods of low demand, its ASV will be much lower. ASV is an important indicator of an airport's ability to meet the demands placed on its airfield because ASV combines the physical capacity of the airfield, as measured by its weighted hourly capacity, with the characteristics of the users of the airport, as measured by design hour operations. Exhibit 3-6 presents the Renton Municipal Airport's ASV as compared to its annual demand.

**EXHIBIT 3-6: ANNUAL SERVICE VOLUME AND ANNUAL DEMAND**

| Description | 1993 | 1998 | 2003 | 2013 |
|---|---|---|---|---|
| Annual Service Volume | 230,000 | 230,000 | 230,000 | 230,000 |
| Forecast Demand | 112,031 | 149,040 | 152,400 | 163,660 |
| Capacity Surplus (Deficit) | 117,970 | 80,960 | 77,600 | 66,340 |

As evidenced in Exhibits 3-5 and 3-6, the Renton Municipal Airport has sufficient runway capacity to meet the demand for service as measured by the hourly capacity and annual service volume.

## 3.2 TERMINAL AREA

Components of a terminal area complex include the terminal building, automobile access and parking lots, terminal curb frontage, and terminal support facilities. Renton Municipal Airport does not have a centralized passenger terminal facility and existing passenger flow is currently being accommodated through private FBO and air taxi facilities. A discussion on recommended passenger terminal facilities will be presented in Chapter 4, Facility Requirements.

## 3.3 SURFACE ACCESS SYSTEM

The capacity of the access system was reviewed for the following system components:

- Airport access roadways; and
- On Airport Roadways.

### 3.3.1 Access Roadways

The airport access roadway system is important in that it governs entry into the airport. Congestion on these roadways adversely affects airport access. Congestion on a facility is affected by a number of factors, including:

- Roadway Conditions: the geometric characteristics of the street;
- Traffic Conditions: the characteristics of traffic using the facility; and
- Control Conditions: the types of control devices and regulations of the facility.

Exhibit 3-7 tabulates the urban roadway volumes at which congestion problems typically appear.

**EXHIBIT 3-7: CONGESTED VOLUMES OF ROADWAY**

| Roadway Type and Operating Conditions | Volume Per Lane at Congested Levels |
|---|---|
| Suburban highway with considerable interference from cross traffic and roadsides. | 560 vehicles per hour |
| Arterial Street | 480 vehicles per hour |
| Intersection | 500 vehicles per hour |

Source: City of Renton

The major roadways providing access to the airport include Interstate 405, State Highway 167, Logan Avenue, Rainier Avenue North, and Airport Way. Direct access to airport facilities is from Rainier Avenue North and Airport Way. Both roadways are high volume six lane urban arterials with over 30,000 vehicles per day (VPD). According to the Transportation Element of the City of Renton Comprehensive Plan, traffic on Rainier Avenue North is expected to increase by about 40 percent over the next twenty years, while traffic on Airport Way is projected to double in the same time span. Both roadways will experience significant congestion at these levels of demand.

The peak intersection volumes for Rainier Avenue North and Airport Way are in the 600 - 700 vphpl range. Congestion problems typically can begin to occur when entering volumes reach 500 vphpl. Projected traffic increases at the intersection indicate that entering volumes will double in the next twenty years.

Future volume increases on Rainier Avenue North and Airport Way will have an impact on the service levels at the access points to the airport. Of particular concern is the stop sign controlled access on Rainier Avenue North. The continued traffic increase on this roadway will extend vehicle delay.

To offset the anticipated growth in traffic, the City of Renton is employing a multi-modal plan based largely on improvements to transit, High-Occupancy Vehicle (HOV) facilities, and the initiation of Transportation Demand Management (TDM) and Commute Trip Reduction (CTR) measures. These improvements focus on increasing the efficiently of the transportation system, while decreasing the total demand for travel. Forecasts show that Renton will be able to maintain the present overall level of service as measured by travel times (see the *City of Renton Level of Service Documentation* and the *Transportation Element of the Comprehensive Plan*).

### 3.3.2 On Airport Roadways

Direct entrances to the airport are provided at two major locations with a third secondary entrance. At Airport Way and Shattuck Avenue, a signalized intersection provides two entrances and two exit lanes for the site. On the northwest corner of the site a four lane driveway entrance and exit is provided at Rainier Avenue. The exit is stop sign controlled. A secondary entrance is located at the southeast corner of the airport at Logan Way. The physical characteristics of the entrances to the airport pose difficulties for some of the non-conventional vehicle traffic operating at the airport.

These entrances provide access to the Airport Perimeter Road. The Airport Perimeter Road is not part of the public street system, and therefore is used by non-conventional vehicles to move about the airport. Use of the Airport Perimeter Road is light, with an average daily traffic volume of 1900 vpd in 1993. The Airport Perimeter Road has a posted speed limit of 25 mph.

## 3.4 GENERAL AVIATION FACILITY CAPACITY

Determining the capacity of the general aviation facilities at the Renton Municipal Airport is a relatively straightforward process. Using the inventory data from Chapter 1 of this report, on-site inspection, and FBO and based aircraft owners survey forms, the available facilities were analyzed. Actual building or apron usage was not considered in this analysis, but rather generic categories were specified, with capacity expressed in terms of area measurements. Detailed determination of required new facilities will be provided in the following chapter on facility requirements.

## 3.5 SEAPLANE DOCKING AREA

Existing seaplane docking facilities consist of a 31.5 foot wide concrete and wood launch and retrieval ramp and a 6 foot wide floating dock with space for approximately three aircraft. The launch/retrieval ramp is limited in its use by the availability specialized launch/retrieval vehicles, as well as by its location within the existing runway obstacle free area. As with general aviation facilities, a determination of required new facilities will be provided in the next chapter.