Las Vegas McCarran International Airport

Capacity Enhancement Plan

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September 1994

Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, Clark County Department of Aviation, and the airlines and general aviation serving Las Vegas.

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Executive Summary

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA), airport operators, and aviation industry groups have initiated joint Airport Capacity Design Teams at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand, decrease delays, and improve airport efficiency and works to develop a coordinated action plan for reducing airport delay. Over 35 Airport Capacity Design Teams have either completed their studies or have work in progress.

The need for this program continues. In 1992, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 32 by 2003.

Las Vegas McCarran International Airport (LAS) is, according to FAA forecasts, one of the 32 airports that could exceed 20,000 hours of annual air carrier delay in 2003, if no improvements in capacity are made. Steady growth at LAS has made it one of the busiest airports in the country. Activity at the airport has increased from 4,830,000 passenger enplanements in 1983 to 10,110,634 in 1991, an increase of over 109 percent. In 1983, the airport handled 297,000 aircraft operations (takeoffs and landings), and, in 1991, 398,065 aircraft operations, an increase of 34 percent.

An Airport Capacity Design Team for Las Vegas McCarran International Airport was formed in 1992. The LAS Capacity Team identified and assessed various actions that, if implemented, would increase LAS's capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

Selected alternatives identified by the Capacity Team were tested using computer models developed by the FAA to quantify the benefits provided. Different levels of activity were chosen to represent growth in aircraft operations in order to compare the merits of each action. These annual activity levels are referred to throughout the report as:

- Baseline — 425,000 operations;
- Future 1 — 530,000 operations; and
- Future 2 — 628,000 operations.

The FAA Technical Center calculated annual aircraft delays based on the results of computer simulations that utilized runway use, weather, and operating cost data generated during the Capacity Team study. At the Baseline activity level with the current runway use strategies, the majority of delays were incurred by general aviation and air taxi aircraft. Because of their low operating costs, this resulted in high delay times but low delay costs. Since forecasts predict significant changes in the aircraft fleet mix at future activity levels, operating costs were substantially higher at Future 1 and Future 2 than at Baseline. In addition, with the new runway use strategies developed for the proposed runway extensions, delays at Future 1 and Future 2 were distributed equally among all the aircraft in the fleet, and this further increased average aircraft operating costs at these activity levels.

Figure 3 illustrates capacity and delay curves for LAS. To show operations under visual meteorological conditions (VMC), curves were developed with a south and west flow (Configuration 1 under VFR and Configuration 1A under VFR 2) for the existing airport and for the future airport with the extensions of Runway 1L/19R and Runways 7L/25R and 7R/25L in place. To show operations under instrument meteorological conditions (IMC), curves were developed with a west flow (Configuration 2 under IFR) for the existing airport and for the future airport with the extensions in place.

Figure 3 shows that, for the existing airport, aircraft delays will begin to escalate rapidly under VFR as hourly demand exceeds 110 operations per hour. Figure 4 shows that, while hourly demand exceeds 110 operations per hour only during a single hour at Baseline demand levels, 110 operations per hour is exceeded during the bulk of the day at the demand levels forecast for Future 2. Under IFR, the capacity of the airport is significantly lower. Although IFR operations occur only 2 percent of the time in winter and less than 1 percent of the time in summer, the impact of the associated delays can be critical.

Figure 5 shows how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. Annual delay cost will increase from 110,390 hours or $58.26 million at the Baseline level of operations to 351,460 hours or $489.12 million by Future 1 and 947,160 hours or $1,585.16 million by Future 2. It is important to notice that the ratio of delay to cost is not consistent between the demand levels. This is due to variations in operational strategy and fleet mixes between Baseline, Future 1, and Future 2. Figure 5 also indicates the capacity enhancement alternatives that provide the most significant delay-savings benefits.

Figure 6 illustrates the average delay in minutes per aircraft operation for these alternatives. Under the Do Nothing alternative, if there are no improvements made in airfield capacity, the average delay per operation of 15.6 minutes at the Baseline level of activity will increase to 39.4 minutes per operation by Future 1 and 90.5 minutes per operation by Future 2.

Figure 1. Las Vegas McCarran International Airport

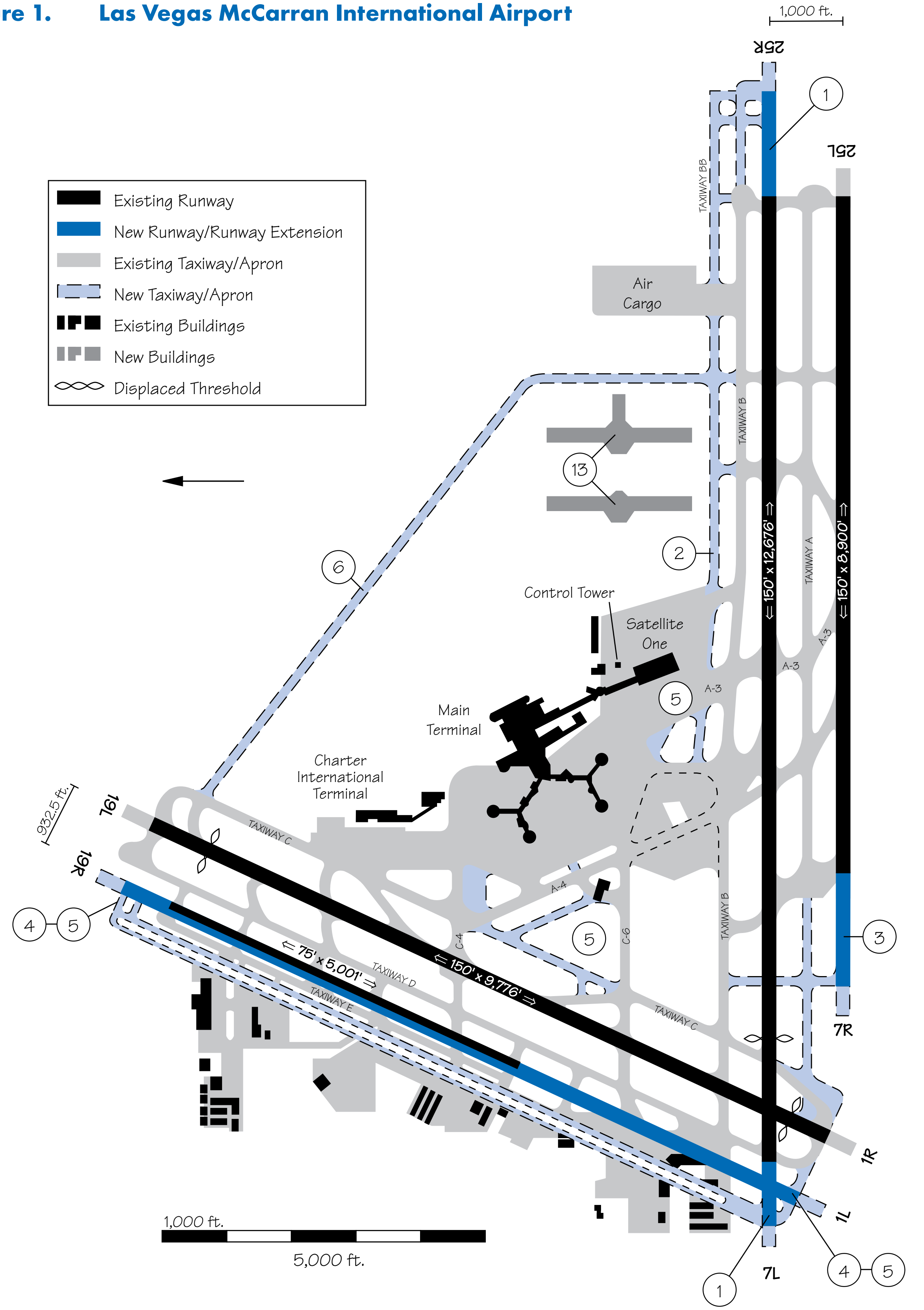


Figure 2. Capacity Enhancement Alternatives and Annual Delay Savings

Airfield Improvements	Estimated Annual Delay Savings[1] (in hours and millions of 1992 dollars) Baseline (425,000)	Future 1 (530,000)	Future 2 (628,000)
1. Extend Runway 7L/25R to 14,400 ft.	60/$0.03	1,370/$2.1	35,130/$63.4
2. Construct parallel Taxiway BB to end [2] of Runway 25R	—	—	—
3. Extend Runway 7R/25L to 10,600 ft.	†	†	†
4. Extend/upgrade Runway 1L/19R to 9,800 ft.	50,750/$5.22	157,160/$183.7	385,160/$632.5
5. Taxiway improvements to support main terminal area and Runway 1L/19R extension	9,460/$11.0	44,690/$68.8	49,050/$81.5
6. Construct Taxiway AC from Taxiway A at end of Runway 25R to Taxiway C at end of Runway 19L	1,980/$2.3	3,480/$5.4	3,880/$6.4
Facilities and Equipment Improvements			
7. Install precision approach system on Runway 19R or 19L	6,590/$8.5	8,330/$13.6	10,640/$18.4
8. Install precision approach system on Runway 1R or 1L	6,860/$8.8	10,110/$16.5	13,050/$22.5
Operational Improvements			
9. Reduce in-trail separation from 3.0 nm to 2.5 nm for like classes of aircraft in IFR	2,750/$3.5	3,160/$5.2	3,850/$6.7
10. Evaluate effect of simultaneous operations on intersecting runways (SOIR) with tail winds on dry runways	330/$0.1	6,580/$14.4	18,180/$40.4
11. Evaluate effect of operations on wet runways	50/$0.01	730/$1.6	2,020/$4.5
12. Enhance reliever and GA airport system			
12a. 30 percent of small/slow aircraft	16,520/$3.9	53,140/$79.2	133,570/$272.2
12b. 60 percent of small/slow aircraft	21,160/$9.3	70,270/$105.7	258,160/$479.4
13. Evaluate impact of terminal expansion (68 additional aircraft parking positions)	960/$1.1	40,400/$62.6	122,940/$204.7

1. The delay savings benefits of these alternatives are not necessarily additive.
2. The delay savings benefits of Taxiway BB have been included as a part of the benefits of the terminal expansion program (see Alternative 13).

† No delay savings were estimated for this alternative. There is a description of this improvement in Section 2 — Capacity Enhancement Alternatives

Figure 3. Airport Capacity Curves — Hourly Flow Rate Versus Average Delay

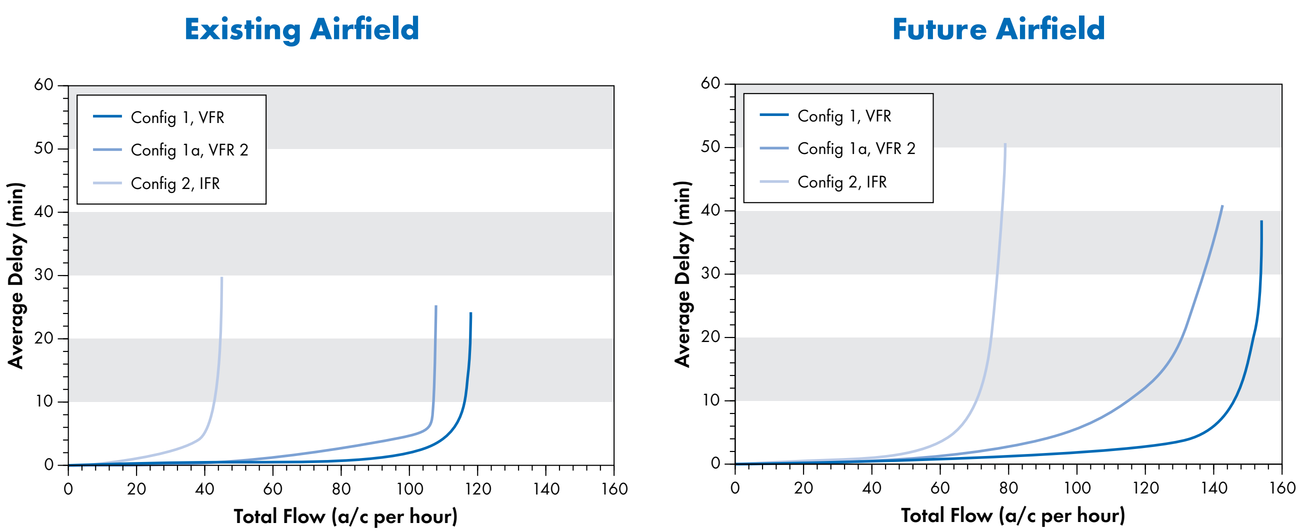


Figure 4. Profile of Daily Demand — Hourly Distribution

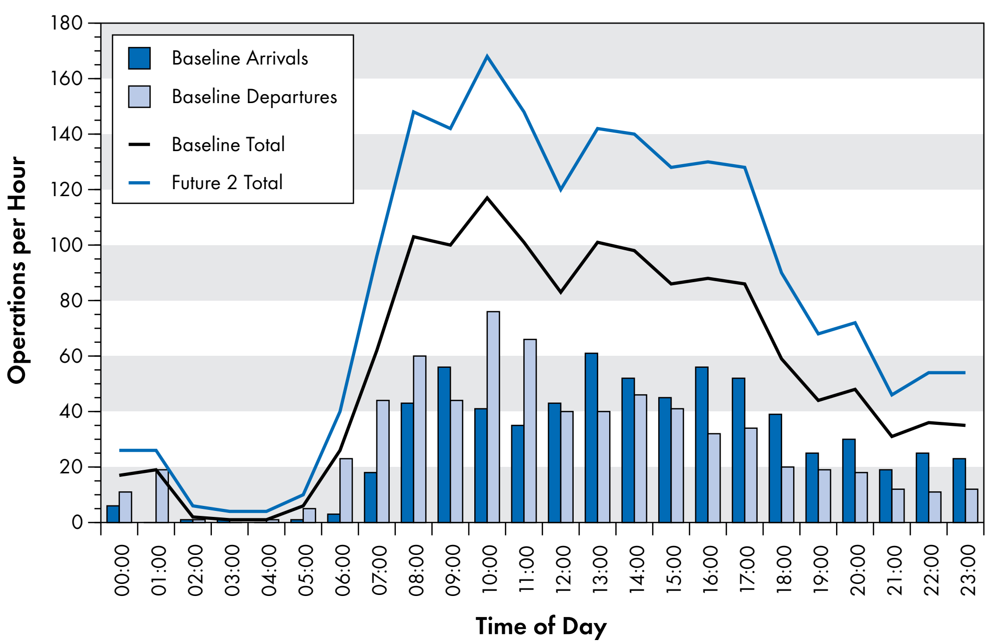


Figure 5. Annual Delay Costs — Capacity Enhancement Alternatives

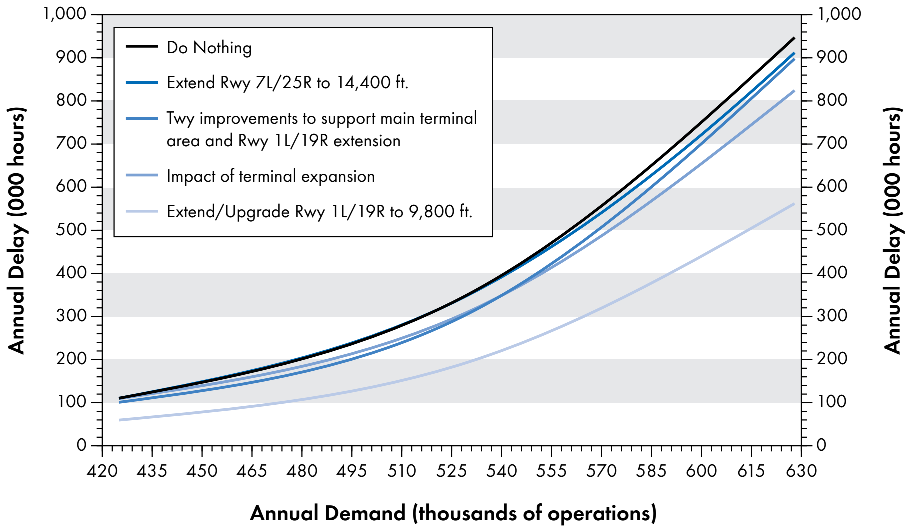
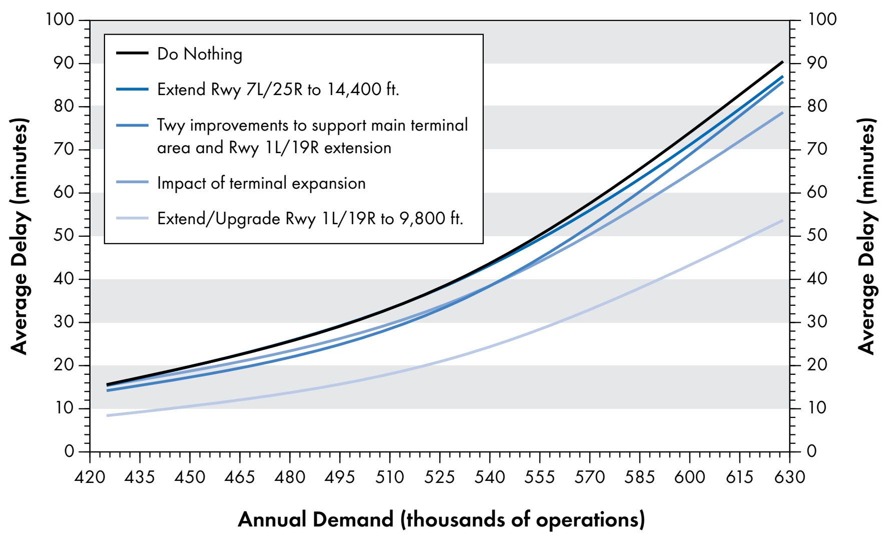


Figure 6. Average Delays — Capacity Enhancement Alternatives



Major Recommendations	Annual Delay Savings			
	Future 1		Future 2	
Alternatives	Hours	1992 $ M	Hours	1992 $ M
• Extend/upgrade Runway 1L/19R to 9,800 feet	157,160	$183.65	385,160	$632.49
• Evaluate impact of terminal expansion (68 additional aircraft parking positions)	40,400	$62.55	122,940	$204.69
• Taxiway improvements to support main terminal area and Runway 1L/19R extension	44,690	$68.81	49,050	$81.46
• Extend Runway 7L/25R to 14,400 feet	1,370	$2.07	35,130	$63.42

Section 1

Introduction

Background

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA) asked the aviation community to study the problem of airport congestion through the Industry Task Force on Airport Capacity Improvement and Delay Reduction chaired by the Airport Operators Council International.

By 1984, aircraft delays recorded throughout the system highlighted the need for more centralized management and coordination of activities to relieve airport congestion. In response, the FAA established the Airport Capacity Program Office, now called the Office of System Capacity and Requirements (ASC). The goal of this office and its capacity enhancement program is to identify and evaluate initiatives that have the potential to increase capacity, so that current and projected levels of demand can be accommodated within the system with a minimum of delay and without compromising safety or the environment.

In 1985, the FAA initiated a renewed program of Airport Capacity Design Teams at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand and works to develop a coordinated action plan for reducing airport delay. Over 30 Airport Capacity Design Teams have either completed their studies or have work in progress.

The need for this program continues. In 1992, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 32 by 2003. The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

Las Vegas McCarran International Airport

Las Vegas McCarran International Airport is one of the 32 airports that the FAA has forecast could exceed 20,000 hours of annual aircraft delay by 2003, if no improvements in capacity are made. In the past decade, McCarran International Airport (LAS) has been one of the nation's busiest airports. Enplanements at LAS rose from 4,830,000 in 1983 to 10,110,634 in 1991, an increase of over 109 percent. LAS's total aircraft operations (one takeoff or one landing equals one operation) reached 398,065 in 1991, an increase of 34 percent over the 297,000 aircraft operations the airport handled in 1983.

McCarran International Airport is owned by Clark County, Nevada, and operated through the Clark County Department of Aviation. The airport is currently situated on about 2,800 acres and is at an elevation of 2,175 feet above mean sea level. The airfield has four asphalt-paved runways.

- Runway 7L/25R, which is oriented east-west, is 12,636 feet long and is used primarily by air carrier aircraft. The landing threshold of Runway 7L is displaced 1,667 feet to the east to provide the required obstacle clearance over an antenna west of the Airport. The instrument landing system (ILS) on Runway 25L is for Category I (CAT I) approaches. The 1.04 percent effective gradient of Runway 7L/25R is upward to the west.
- Runway 7R/25L is 8,900 feet long and is also used primarily by air carrier aircraft. Runway 7R/25L is parallel to and 1,000 feet south of Runway 7L/25R, when measured from centerline to centerline of the two runways. The ILS on Runway 25L is also for CAT I approaches. The 1.04 percent effective gradient of Runway 7R/25L is upward to the west.
- Runway 1R/19L, which is oriented northeast-southwest, is 9,776 feet long and is also used primarily by air carrier aircraft. The landing threshold of Runway 1R is displaced 500 feet to the northeast to provide obstacle clearance over the Union Pacific Railroad tracks. The landing threshold of Runway 19L is displaced 874 feet to the southwest to provide obstacle clearance over a nearby pole. The 0.99 percent effective gradient of Runway 1R/19L is upward to the southwest.

- Runway 1L/19R is 5,001 feet long and 75 feet wide and is used primarily by general aviation and commuter aircraft. Runway 1L/19R is parallel to and 862.5 feet northwest of Runway 1R/19L. The 1.06 percent effective gradient of Runway 1L/19R is upward to the southwest.

Each of the four runways has a parallel taxiway that extends the entire length of the runway. Runways 7R/25L and 1R/19L have angled exit taxiways to expedite aircraft exiting the runway after landing. Aircraft holding pads are located at the east end of Runways 7L/25R and 7R/25L, at the north end of and between Runways 1L/19R and 1R/19L, and southwest of the Main Terminal.

Las Vegas Airport Capacity Design Team

An Airport Capacity Design Team for McCarran International Airport was formed in 1992. The LAS Capacity Team identified and assessed various actions that, if implemented, would increase capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

This report has established benchmarks for development based upon traffic levels and not upon any definitive time schedule, since actual growth can vary year to year from projections. As a result, the report should retain its validity until the highest traffic level is attained regardless of the actual dates paralleling the development.

A Baseline benchmark of 425,000 aircraft operations (takeoffs and landings) was established based on the annual traffic level for 1992. Two future traffic levels, Future 1 and Future 2, were established at 530,000 and 628,000 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Las Vegas. If no improvements are made at LAS, annual delay levels and delay costs are expected to increase from an estimated 110,390 hours and \$58.26 million at the Baseline activity level to 351,460 hours and \$489.12 million by the Future 1 demand level and 947,160 hours and \$1,585.16 million by Future 2.

The Capacity Team studied various proposals with the potential for increasing capacity and reducing delays at LAS. The improvements evaluated by the Capacity Team are delineated in Figure 2 and described in some detail in Section 2, Capacity Enhancement Alternatives.

Objectives

The major goal of the Capacity Team was to identify and evaluate proposals to increase airport capacity, improve airport efficiency, and reduce aircraft delays. In achieving this objective, the Capacity Team:

- Assessed the current airport capacity.
- Examined the causes of delay associated with the airfield, the immediate airspace, and the apron and gate-area operations.
- Evaluated capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational improvements, airfield development, and operational improvements.

Scope

The Capacity Team limited its analyses to aircraft activity within the terminal area airspace and on the airfield. They considered the operational benefits of the proposed airfield improvements, but did not address environmental, socioeconomic, or political issues regarding airport development. These issues need to be addressed in future airport planning studies, and the data generated by the Capacity Team can be used in such studies.

Methodology

The Capacity Team, which included representatives from the FAA, the Clark County Aviation Department, the State of Nevada Department of Transportation, and various aviation industry groups (see Appendix A), met periodically for review and coordination. The Capacity Team members considered suggested capacity improvement alternatives proposed by the FAA's Office of System Capacity and Requirements, Technical Center, and Regional Aviation Capacity Program Manager, and by other members of the Team. Alternatives that were considered practicable were developed into experiments that could be tested by simulation modeling. The FAA Technical Center's Aviation Capacity Branch provided expertise in airport simulation modeling. The Capacity Team validated the data used as input for the simulation modeling and analysis and reviewed the interpretation of the simulation results. The data, assumptions, alternatives, and experiments were continually reevaluated, and modified where necessary, as the study progressed. A primary goal of the study was to develop a set of capacity-producing recommendations, complete with planning and implementation time horizons.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at LAS. Proposed improvements were analyzed in relation to current and future demands with the help of FAA computer models, the Airport and Airspace Simulation Model (SIMMOD) and the Runway Delay Simulation Model (RDSIM). Appendix B briefly explains the models.

The simulation models considered air traffic control procedures, airfield improvements, and traffic demands. Alternative airfield configurations were prepared from present and proposed airport layout plans. Various configurations were evaluated to assess the benefit of projected improvements. Air traffic control procedures and system improvements determined the aircraft separations to be used for the simulations under both VFR and IFR.

Air traffic demand levels were derived from *Official Airline Guide* data, historical data, and Capacity Team and other forecasts. Aircraft volume, mix, and peaking characteristics were considered for each of the three different demand forecast levels (Baseline, Future 1, and Future 2). From this, annual delay estimates were determined based on implementing various improvements. These estimates took into account historic variations in runway configuration, weather, and demand. The annual delay estimates for each configuration were then compared to identify delay reductions resulting from the improvements. Following the evaluation, the Capacity Team developed a plan of recommended alternatives for consideration.

SECTION 2

CAPACITY ENHANCEMENT ALTERNATIVES

Background

The capacity enhancement alternatives are categorized and discussed under the following headings:

- Airfield Improvements
- Facilities and Equipment Improvements
- Operational Improvements

Figure 1 shows the current layout of the airport, plus the airfield improvements considered by the Capacity Team.

Figure 2 lists the capacity enhancement alternatives evaluated by the Capacity Team and presents the estimated annual delay savings benefits for selected improvements. The annual delay savings are given for the activity levels Baseline, Future 1, and Future 2, which correspond to annual aircraft operations of 425,000, 530,000, and 628,000 respectively. The delay savings benefits of the improvements are not necessarily additive.

Figure 7 presents the recommended action and suggested time frame for each capacity enhancement alternative considered by the Capacity Team.

Figure 7. Capacity Enhancement Alternatives Studied and Recommended Actions

Airfield Improvements	Action	Time Frame	Responsible Agency
1. Extend Runway 7L/25R to 14,400 ft.	Recommended	Completed	DOA
2. Construct parallel Taxiway BB to end of Runway 25R	Recommended	Future 1	DOA
3. Extend Runway 7R/25L to 10,600 ft.			
4. Extend/upgrade Runway 1L/19R to 9,800 ft.	Recommended		DOA
5. Taxiways improvements to support main terminal area and Runway 1L/19R extension	Recommended		DOA
6. Construct Taxiway AC from Taxiway A at end of Runway 25R to Taxiway C at end of Runway 19L	Not Recommended	Future 1	DOA

Facilities and Equipment Improvements	Action	Time Frame	Responsible Agency
7. Install precision approach system on Runway 19R or 19L	Recommended	Future 1	FAA
8. Install precision approach system on Runway 1R or 1L	Recommended	Future 1	FAA

Operational Improvements	Action	Time Frame	Responsible Agency
9. Reduce in-trail separation from 3.0 nm to 2.5 nm for like classes of aircraft in IFR	Recommended	Future 1	DOA/FAA
10. Evaluate effect of simultaneous operations on intersecting runways (SOIR) with tail winds on dry runways	Recommended	Future 1	FAA
11. Evaluate effect of operations on wet runways	Recommended	Future 1	FAA
12. Enhance reliever and GA airport system	Recommended	Future 1	DOA/FAA
13. Evaluate impact of terminal expansion (68 additional aircraft parking positions)	Recommended	Future 1	All Agencies[3]

3. All Agencies = FAA, DOA, and the airlines.

Airfield Improvements

1. Extend Runway 7L/25R to 14,400 feet.

Runway 7L/25R, which intersects Runway 1R/19L, is the primary departure runway for the Airport. Air traffic control procedures for operations conducted on intersecting runways are, by necessity, more restrictive than for operations conducted on non-intersecting or parallel runways.

This project, completed during the course of this study, extended Runway 7L/25R approximately 400 feet to the west and 1,400 feet to the east. The proximity of Eastern Avenue on the east and Las Vegas Boulevard on the west limited the ability to extend the runway beyond a certain length without incurring significantly greater expense to realign or depress these roadways.

The extension of Runway 7L/25R to 14,400 feet increased the capability for nonstop international passenger or long-haul air cargo operations to international destinations overseas using fully loaded aircraft.

The extension required the relocation of the ILS localizer antenna for Runway 25R. The antenna, originally located near the west end of the existing runway, was already programmed for upgrade and relocation. The new location is compatible with the runway extension.

Estimated 1993 project cost was $14.0 million.

Annual delay savings at the Baseline activity level will be 60 hours or $0.03 million; at Future 1, 1,370 hours or $2.07 million; and, at Future 2 activity levels, 35,130 hours or $63.42 million.

2. Construct parallel Taxiway BB to end of Runway 25R.

An additional parallel taxiway, Taxiway BB, on the north side of Runway 7L/25R, north of Taxiway B, would allow two-way traffic for arriving and departing aircraft to taxi to and from the new terminal complex and the eastern extension of Runway 25R, thus improving the flow of ground traffic and reducing taxi interference and delays. The delay savings benefits of Taxiway BB have been included as a part of the benefits of the terminal expansion program (see Alternative 13).

Estimated 1993 project cost is $1.75 million.

3. Extend Runway 7R/25L to 10,600 feet.

This project would extend Runway 7R/25L approximately 1,600 feet to the west. The extension would allow most of the aircraft currently operating at the Airport to depart from the runway and thus would provide additional airfield flexibility as well as an increase in overall capacity.

Runway 7R/25L is separated from Runway 7L/25R by 1,000 feet. The two parallel runways could support dual arrival and departure streams, but only under VFR. Under IFR, runways separated by less than 2,500 feet must be treated as a single runway.

Estimated 1993 project cost is $3.2 million.

4. Extend/upgrade Runway 1L/19R to 9,800 feet.

This project would extend the runway pavement length to 9,800 feet, approximately the same length as Runway 1R/19L.

Extending, widening, and strengthening Runway 1L/19R to accommodate air carrier operations would provide an additional air carrier runway. Airport flexibility will be increased even though, due to runway safety area and object free area requirements, the actual runway lengths available for arrival and departure operations would not be equal to the full length of the pavement in either direction.

A further extension Runway 1R/19L is restricted by the availability of land on the west side of the airfield and the proximity of Tropicana Avenue to the north and Las Vegas Boulevard to the southwest. The potential centerline-to-centerline separation of Runway 1L/19R from Runway 1R/19L is impacted by the need to provide adequate areas for fixed-base operators and general aviation facilities on the west side of the airfield. Prior to extending the runway, it will be necessary to relocate the Union Pacific Railroad tracks which pass through the southwest corner of the Airport property, however, estimated savings indicate that this project will be cost effective.

Estimated 1993 project cost of alternatives 4 and 5 combined is $63.0 million.

Annual delay savings at the Baseline activity level would be 50,750 hours or $5.22 million; at Future 1, 157,160 hours or $183.65 million; and, at Future 2 activity levels, 385,160 hours or $632.49 million.

5. Taxiways improvements to support main terminal area and Runway 1L/19R extension.

The extension of Taxiway C, construction of Taxiway AA4, and upgrade of the Taxiway A3 area will enable the reorganization of aircraft movement for operation in an orderly fashion in and around the Main Terminal and Satellite One on the east side of the Airport. These improvements will be used primarily by scheduled air carrier, charter, and international operators. Theses improvements are also expected to facilitate movement of aircraft between the east and west sides of the airport.

Extending Taxiway C from Exit C4 to Exit C6 would provide for a parallel taxiway along the entire length of the east side of Runway 1R/19L. This would improve the flow of ground traffic and reduce taxi interference and delays.

The construction of exits and connectors, an extension of Taxiway E, and an apron edge taxilane parallel to Taxiway E would facilitate aircraft movement throughout the west side of the airport. This would support the continuing needs of general aviation and non-scheduled aircraft operations by providing for improved access to various apron areas for either parking or loading and unloading activities.

The addition of exits and connectors on Runway 1L/19R would aid in reducing occupancy time for arrivals on the runway. By reducing arrival runway occupancy times, the airfield can be operated more efficiently when arrivals and departures are evenly mixed. Additionally, a reduction in runway occupancy times to an average of 50 seconds or less would facilitate reducing arrival-to-arrival in-trail separations on final approach to 2.5 nm for aircraft of similar class (see alternative 10), thereby providing an important additional capacity advantage.

As a part of the construction of an upgraded Runway 1L/19R, a parallel taxiway and taxilane system should be built west of the new runway. Extending, widening, and strengthening Taxiway E would provide for a parallel taxiway the entire length of the runway. The current FAA requirement for runway-to-taxiway separation is 400 feet.

Constructing an apron edge taxilane parallel to Taxiway E would allow for two-way traffic, thus improving the flow of ground traffic and reducing taxi interference and delays.

Estimated 1993 project cost of alternatives 4 and 5 combined is $63.0 million.

Annual delay savings at the Baseline activity level would be 9,460 hours or $11.01 million; at Future 1, 44,690 hours or $68.81 million; and, at Future 2 activity levels, 49,050 hours or $81.47 million.

6. Construct Taxiway AC from Taxiway A at end of Runway 25R to Taxiway C at end of Runway 19L.

Constructing Taxiway AC from Taxiway A at the east end of Runway 7L/25R to Taxiway C at the north end of Runway 1R/19L would improve access to the new terminal complex, improve the flow of ground traffic, and reduce taxi interference and delays.

Annual delay savings at the Baseline activity level would be 1,980 hours or $2.26 million; at Future 1, 3,480 hours or $5.39 million; and, at Future 2 activity levels, 3,880 hours or $6.40 million.

Facilities and Equipment Improvements

7. Install precision approach system on Runway 19R or 19L.

Instrument flight rules (IFR) that restrict operations occur about 2 percent of the time in winter and less than 1 percent of the time in summer, but the impact of the associated delays can be significant. Currently only Runways 25L and 25R are equipped with ILSs. Installing a precision approach system on Runway 19R or 19L would provide additional flexibility in the use of runways for precision approach, thereby helping to maintain capacity during instrument meteorological conditions (IMC).

Under VFR, it is common to use converging runways for independent streams of arriving aircraft. Because of the reduced ceilings and visibility associated with operations under IFR, the FAA has established a procedure for conducting simultaneous instrument approaches to converging runways in IMC. This procedure uses non-overlapping Terminal Instrument Procedures (TERPS) obstacle-clearance surfaces as a means of separation for aircraft executing simultaneous missed approaches. It requires a 3 nm separation between the missed approach points on each approach. "TERPS+3" (as this procedure is often called) is an independent approach procedure that requires no dependency between the two aircraft on converging approaches. Installing a precision approach system on Runway 19L would enable converging IFR approaches to Runways 19L and 25L.

Annual delay savings at the Baseline activity level would be 6,590 hours or $8.48 million; at Future 1, 8,330 hours or $13.58 million; and, at Future 2 activity levels, 10,640 hours or $18.38 million.

8. Install precision approach system on Runway 1R or 1L.

IFR that restrict operations occur about 2 percent of the time in winter and less than 1 percent of the time in summer, but the impact of the associated delays can be significant. Currently only Runways 25L and 25R are equipped with ILSs. Installing a precision approach system on Runway 1R or 1L would provide additional flexibility in the use of runways for precision approach, thereby helping to maintain capacity during IMC.

Under VFR, it is common to use converging runways for independent streams of arriving aircraft. Because of the reduced ceilings and visibility associated with operations under IFR, the FAA has established a procedure for conducting simultaneous instrument approaches to converging runways in IMC. This procedure uses non-overlapping Terminal Instrument Procedures (TERPS) obstacle-clearance surfaces as a means of separation for aircraft executing simultaneous missed approaches. It requires a 3 nm separation between the missed approach points on each approach. "TERPS+3" (as this procedure is often called) is an independent approach procedure that requires no dependency between the two aircraft on converging approaches. Installing a precision approach system on Runway 1R would enable converging IFR approaches to Runways 1R and 25L.

Annual delay savings at the Baseline activity level would be 6,860 hours or $8.83 million; at Future 1, 10,110 hours or $16.46 million; and, at Future 2 activity levels, 13,050 hours or $22.52 million.

Operational Improvements

9. Reduce in-trail separation from 3.0 nm to 2.5 nm for like classes of aircraft in IFR.

Reducing separation minimums to 2.5 nm for aircraft of similar class would increase arrival rates and runway capacity. Aircraft capable of takeoff weights of 300,000 pounds or more and the Boeing 757 may participate in the separation reduction as trailing aircraft only. Most of the delay savings occur at the highest demand levels under IFR. In order to use reduced final approach in-trail separations, it must be demonstrated that runway occupancy times for arrivals are consistently 50 seconds or less.

Annual delay savings at the Baseline activity level would be 2,750 hours or $3.53 million; at Future 1, 3,160 hours or $5.20 million; and, at Future 2 activity levels, 3,850 hours or $6.73 million.

10. Evaluate effect of simultaneous operations on intersecting runways (SOIR) with tail winds on dry runways.

Approved simultaneous operations on intersecting runways, which include simultaneous takeoffs and landings and/or simultaneous landings, are authorized when a landing aircraft is able to and instructed by the controller to hold short of the intersecting runway. Currently, SOIR are permitted only on dry runways when there is no tailwind.

The runway length available on a hold-short runway is measured from the landing threshold to the intersecting runway edge along the landing runway edge closest to the intersecting runway or from the landing threshold to hold-short markings, lights, or signs when installed.

Annual delay savings at the Baseline activity level would be 50 hours or $0.01 million; at Future 1, 730 hours or $1.59 million; and, at Future 2 activity levels, 2,020 hours or $4.48 million.

11. Evaluate effect of operations on wet runways.

Operational experience has demonstrated that the stopping distances for turbojet aircraft are equivalent on well maintained and grooved runways in both wet and dry conditions. Demonstrations of simultaneous operations on intersecting wet runways conducted at Boston Logan, Greater Pittsburgh, and Chicago O'Hare have shown the potential of standardizing these type operations. Procedural development is underway.

Annual delay savings at the Baseline activity level would be 330 hours or $0.11 million; at Future 1, 6,580 hours or $14.40 million; and, at Future 2 activity levels, 18,180 hours or $40.35 million.

12. Enhance reliever and general aviation (GA) airport system.

Reliever and GA airports can ease capacity constraints by attracting small/slow aircraft away from primary airports, especially where small/slow aircraft constitute a significant portion of operations. The segregation of aircraft operations by size and speed increases effective capacity because required time and distance separations are reduced between planes of similar size and speed.

With 30 percent of LAS's small/slow aircraft operating out of reliever airports, there would be an annual delay savings at the Baseline activity level of 16,520 hours or $3.93 million; at Future 1, 53,140 hours or $79.24 million; and, at Future 2 activity levels, 133,570 hours or $272.24 million.

With 60 percent of LAS's small/slow aircraft operating out of reliever airports, there would be an annual delay savings at the Baseline activity level of 21,160 hours or $9.30 million; at Future 1, 70,270hours or $105.68 million; and, at Future 2 activity levels, 258,160 hours or $479.43 million.

Every effort should be made to accommodate these aircraft at enhanced "reliever airports" with easy access to various locations within the metropolitan area. The reliever airports would need to provide services that are appropriate for the category of users at each airport.

13. Evaluate impact of terminal expansion (68 additional aircraft parking positions).

The existing passenger terminal complex provides 60 aircraft parking positions and consists of three structures — the Main Terminal, Satellite One, and the Charter International Terminal. The Main Terminal and Satellite One are joined by an automated transit system.

Future passenger terminal complex improvements include: the addition of four aircraft parking positions between the Main Terminal building and Satellite One; expansion of the Main Terminal building to provide additional ticketing, parking, and baggage claim facilities; and the eventual addition of new Concourses D and E east of the existing terminal complex that would provide 64 aircraft parking positions. The construction of Concourses D and E will include both the taxiway system directly associated with them and the parallel Taxiway BB to Runway 7L/25R (see Alternative 2). The construction of Concourses D and E will require the construction of a new automated transit system.

Annual delay savings at the Baseline activity level would be 960 hours or $1.13 million; at Future 1, 40,400 hours or $62.55 million; and, at Future 2 activity levels, 122,940 hours or $204.69 million.

Section 3

Summary of Technical Studies

Overview

The Las Vegas McCarran International Airport Capacity Team evaluated the efficiency of the existing airfield and the proposed future configurations. A brief description of the computer models and methodology used can be found in Appendix B. Certain standard inputs were used to reflect the operating environment at LAS. Details can be found in the data packages produced by the FAA Technical Center during the study. The potential benefits of various improvements were determined by examining airfield capacity, airfield demand, and average aircraft delays.

Figure 8 shows current airfield weather conditions. Figure 9 provides the daily traffic demand distribution by aircraft class under VFR and IFR for the fleet operating at LAS for the three demand levels, and Figure 10 breaks down the annual traffic demand distribution for each demand level. Figure 11 delineates runway utilization under different conditions of airfield weather by providing percentage of use for various runway configurations. Figure 12 illustrates these runway configurations for the existing airfield, and Figure 13, for the future airfield with the extension and upgrade of Runway 1L/19R and the extensions of Runways 7L/25R and 7R/25L in place.

The fleet mix at LAS has a weighted-average direct operating cost of $1,140 per hour, or $19 per minute at the baseline activity level; $1,560 per hour, or $26 per minute, at Future 1; and $1,680 per hour, or $28 per minute at Future 2. However, it is important to notice that the ratio of delay to cost is not consistent between the demand levels. This is due to variations in operational strategy and fleet mixes between Baseline, Future 1, and Future 2. These figures represent the costs for operating the aircraft and include such items as fuel, maintenance, and crew costs, but they do not consider lost passenger time, disruption to airline schedules, or any other intangible factors.

Daily operations corresponding to an average day in the peak month were used for each of the forecast periods. The Airport and Airspace Simulation Model (SIMMOD) and the Runway Delay Simulation Model (RDSIM) were used to determine aircraft delays during peak periods. Delays were calculated for current and future conditions. Daily delays were annualized to measure the potential economic benefits of the proposed improvements. The annualized delays provided a basis for comparing the benefits of the proposed changes. The benefits associated with various runway use strategies were also identified. The cost of a particular improvement was measured against its annual delay savings. This comparison indicated which improvements would be the most effective.

For expected increases in demand, a combination of improvements can be implemented to allow airfield capacity to increase while aircraft delays are minimized.

Annual aircraft delays were calculated based on the results of SIMMOD and RDSIM computer simulations that utilized runway use, weather, and operating cost data generated during the Capacity Team study. At LAS, for the Baseline activity level with the current runway use strategies, the majority of delays were incurred by general aviation and air taxi aircraft. Because of their low operating costs, this resulted in high delay times but low delay costs at Baseline demand levels. Since forecasts predict significant changes in the aircraft fleet mix at future activity levels, operating costs were substantially higher at Future 1 and Future 2 than at Baseline. In addition, with the new runway use strategies developed for the proposed runway extensions, delays at Future 1 and Future 2 were distributed equally among all the aircraft in the fleet, and this further increased average aircraft operating costs at these activity levels.

Figure 8. Airfield Weather

	Ceiling/Visibility	Winter	Summer
VFR	5,000 feet and above/7 sm and above	93.0%	96.0%
VFR 2	1,000 to 5,000 feet/3 to 7 sm	5.0%	3.5%
IFR	Below 1,000 feet/below 3 sm	2.0%	0.5%
	Total	100%	100%

VFR – Visual Flight Rules IFR – Instrument Flight Rules sm – statute miles

Figure 9. Daily Traffic Demand Distribution by Aircraft Class

Aircraft Class	Aircraft Types	Baseline		Future 1		Future 2	
		VFR	IFR	VFR	IFR	VFR	IFR
Class 4	Single-engine props 12,5000 lbs. or less	25%	21%	9%	7%	6%	4%
Class 3	Twin-engine props 12,500 lbs. or less	20%	17%	10%	8%	9%	8%
Class 2	Large aircraft 12,500 to 300,000 lbs. & small jets	50%	57%	74%	77%	76%	78%
Class 1	Heavy aircraft over 300,000 lbs.	5%	5%	7%	8%	9%	10%

Note: Composite (weighted) distribution of winter and summer demands.

Figure 10. Annual Traffic Demand Distribution

Demand	Air Carrier	Air Taxi	General Aviation	Military
Baseline	49%	25%	23%	3%
Future 1	65%	23%	10%	2%
Future 2	67%	23%	8%	2%

Figure 11. Runway Configuration Percentage Use

Configuration (see Figure 12)		1 S & W	1A S & W	2 W	3 S	4 S & E	5 E	6 N	7 NW	8 NE	Total
VFR	Winter	76%			3%	0.5%	0.5%	4%	8%	1%	93%
	Summer	80%			3%	0.5%	0.5%	3%	8%	1%	96%
VFR 2	Winter		5%								5%
	Summer		3.5%								3.5%
IFR	Winter			2%							2%
	Summer			0.5%							0.5%

Figure 12. Existing Runway Configurations

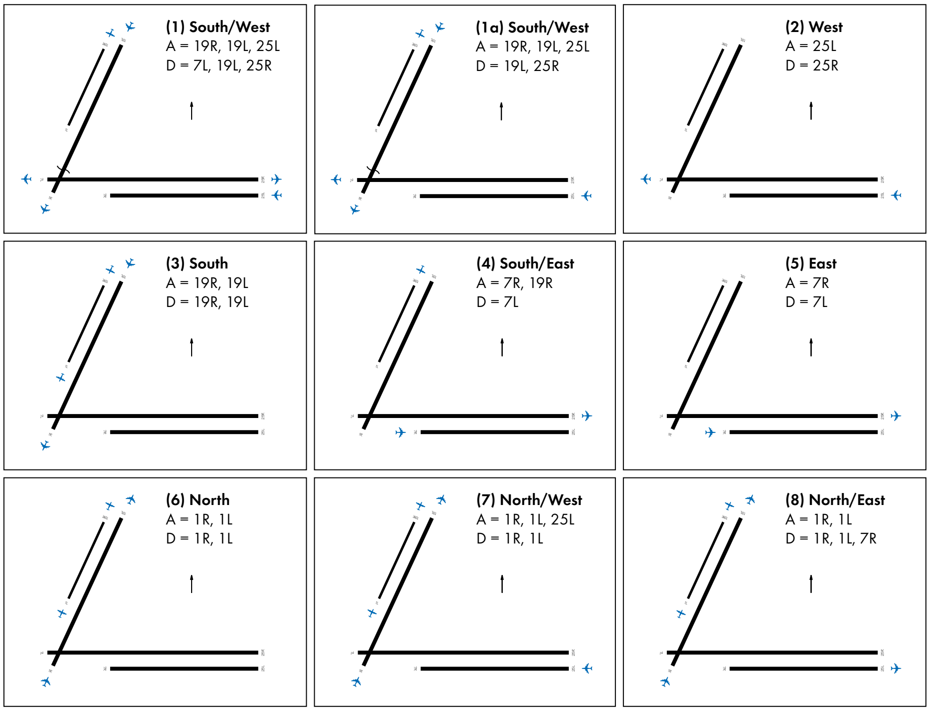
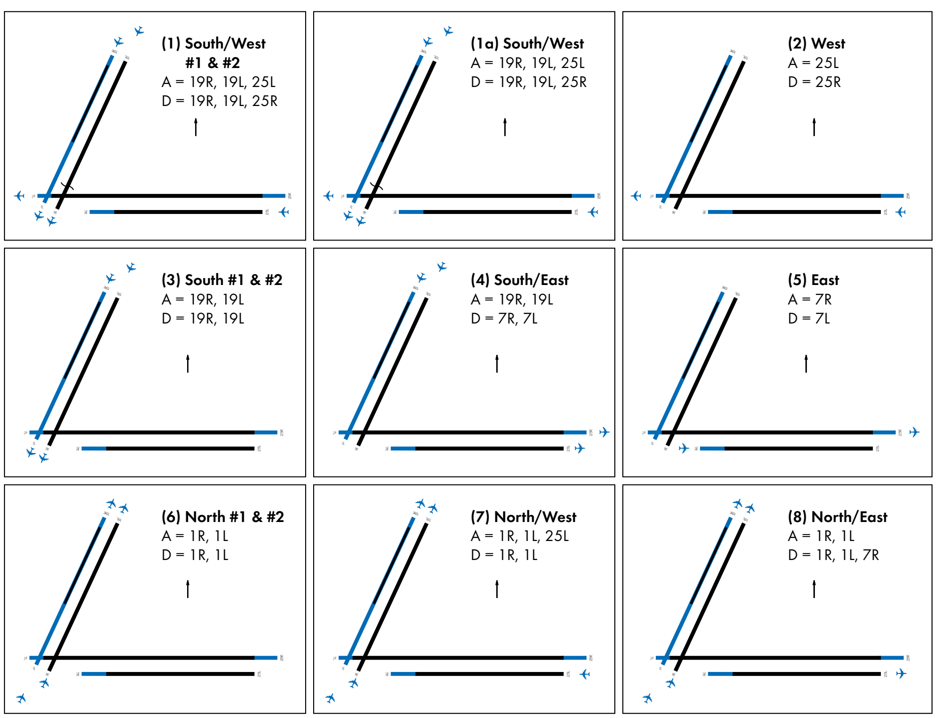


Figure 13. Future Runway Configurations



Airfield Capacity

The LAS Capacity Team defined airfield capacity to be the maximum number of aircraft operations (landings or takeoffs) that can take place in a given time. The following conditions were considered:

- Level of delay
- Airspace constraints
- Ceiling and visibility conditions
- Runway layout and use
- Aircraft mix
- Percent arrival demand

Figure 14 illustrates the average-day, peak-month demand levels for LAS for each of the three annual activity levels used in the study, Baseline, Future 1, and Future 2, for both the winter and the summer schedules.

Figure 15 illustrates capacity and delay curves for LAS. To show operations under visual meteorological conditions (VMC), curves were developed with a south and west flow (Configuration 1 under VFR and Configuration 1A under VFR 2) for the existing airport and for the future airport with the extensions of Runway 1L/19R and Runways 7L/25R and 7R/25L in place. To show operations under instrument meteorological conditions (IMC), curves were developed with a west flow (Configuration 2 under IFR) for the existing airport and for the future airport with the extensions in place. These curves are based on the assumption that arrival and departure demand are randomly distributed within the hour, with a 50/50 split of arrivals and departures. Other patterns of demand can alter the demand/delay relationship.

The curves in Figure 15 illustrate the relationship between airfield capacity, stated in the number of operations per hour, and the average delay per aircraft — as the number of aircraft operations per hour increases, the average delay per operation increases exponentially.

Figure 16 illustrates the hourly profile of daily demand for the Baseline activity level for both the winter and the summer schedules. It also includes curves that depict the profile of daily operations for Future 2 activity levels.

Comparing the information in Figures 15 and 16 shows that, for the existing airport configuration:

- Aircraft delays will begin to escalate rapidly under VFR as hourly demand exceeds 110 operations per hour.
- While hourly demand exceeds 110 operations per hour only during a single hour at Baseline demand levels, 110 operations per hour is exceeded during most of the day at the demand levels forecast for Future 2.
- Under IFR, the capacity of the airport is considerably lower. Although IFR operations occur only 2 percent of the time in winter and less than 1 percent of the time in summer, it is apparent that the impact of the associated delays can be significant.

Figure 14. Airfield Demand Levels

Annual Operations		Winter			Summer		
		Operations	24-Hour Day*	Peak Hour	Operations	24-Hour Day*	Peak Hour
Baseline	425,000	198,000	1,130	98	227,000	1,350	117
Future 1	530,000	247,000	1,410	120	283,000	1,680	142
Future 2	628,000	293,000	1,670	144	335,000	1,990	168

* - Average Day, Peak Month

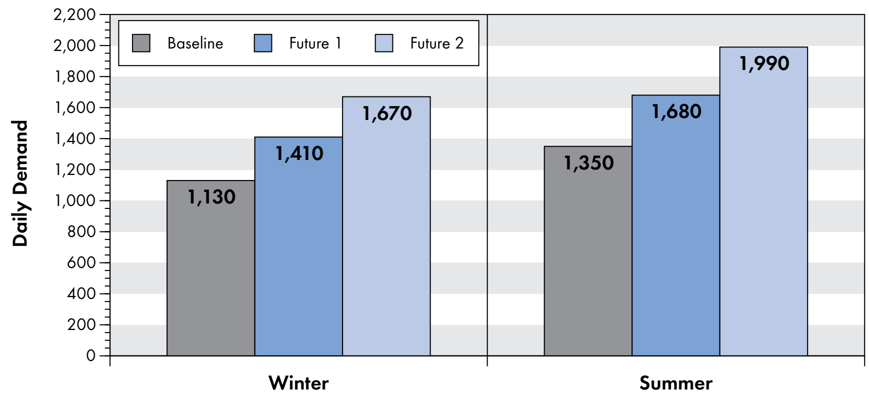


Figure 15. Airport Capacity Curves — Hourly Flow Rate Versus Average Delay

Existing Airfield

Future Airfield

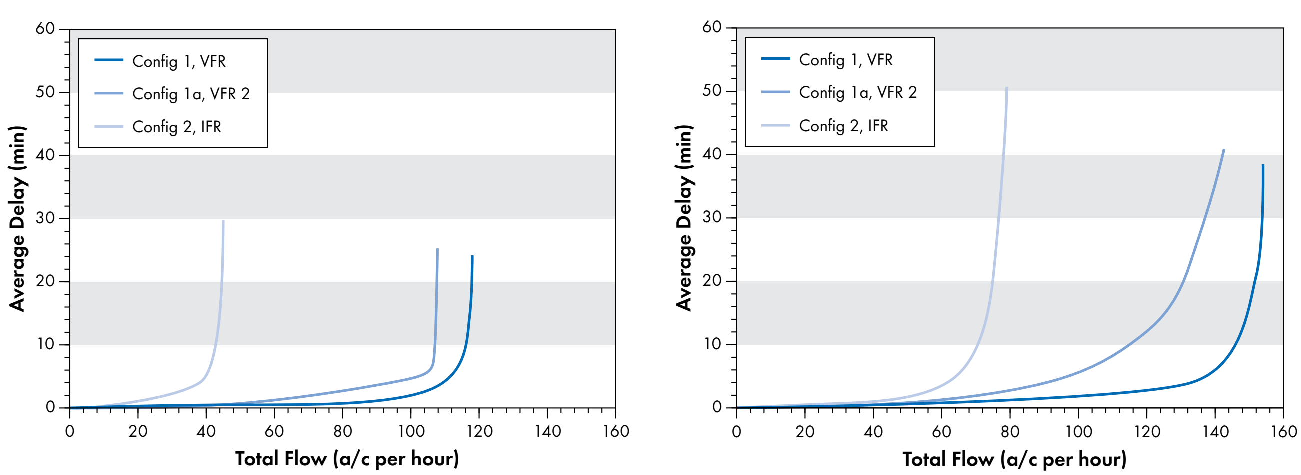
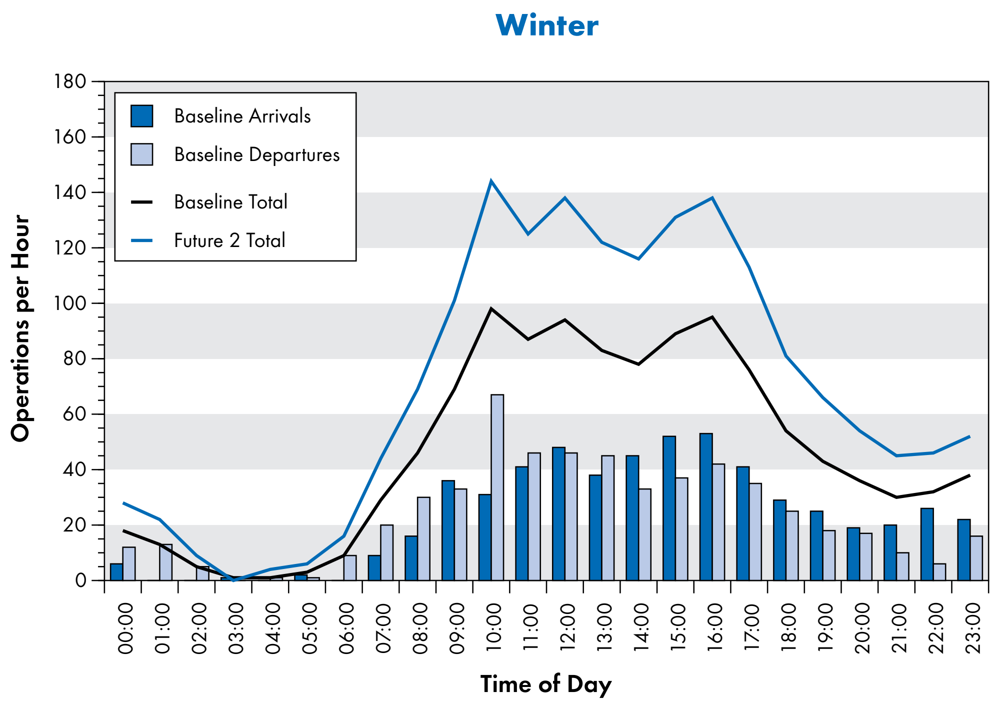
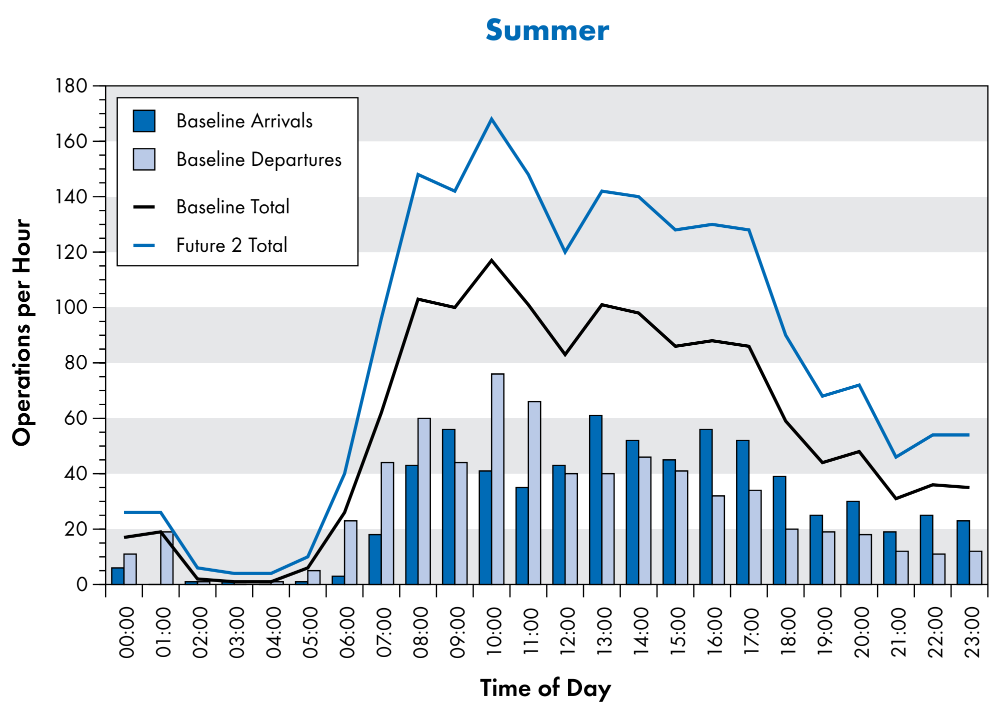


Figure 16. Profile of Daily Demand — Hourly Distribution





Aircraft Delays

Aircraft delay is defined as the time above the unimpeded travel time for an aircraft to move from its origin to its destination. Aircraft delay results from interference from other aircraft competing for the use of the same facilities.

The major factors influencing aircraft delays are:

- Ceiling and visibility conditions
- Airfield and ATC system demand
- Airfield physical characteristics
- Air traffic control procedures
- Aircraft operational characteristics

Average delay in minutes per operation was generated by the Airport and Airspace Simulation Model (SIMMOD). A description of this model is included in Appendix B. If no improvements are made in airport capacity, the average delay per operation of 12.9 minutes at the Baseline level of operations will increase to 30.4 minutes per operation by Future 1 and 71.4 minutes per operation by Future 2. Under this Do Nothing scenario (no improvements in capacity), the annual delay cost could increase as follows:

	Annual Delay Costs	
Demand	**Hours**	**Millions of 1992 $**
Baseline	110,390	$58.26
Future 1	351,460	$489.12
Future 2	947,160	$1,585.16

Conclusions

Figure 17 demonstrates the impact of delays at Las Vegas McCarran International Airport. The chart shows how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the Do Nothing scenario. The graphs also show that the greatest savings in delay costs would be provided by:

- Extending/upgrading Runway 1L/19R to 9,800 feet.
- Evaluating impact of terminal expansion (68 additional aircraft parking positions).
- Taxiway improvements to support main terminal area and Runway 1L/19R extension.
- Extending Runway 7L/25R to 14,400 feet.

Figure 18 illustrates the average delay in minutes per aircraft operation for these alternatives. Under the Do Nothing alternative, if there are no improvements made in airfield capacity, the average delay per operation of 15.6 minutes at the Baseline level of activity will increase to 39.8 minutes per operation by Future 1 and 90.5 minutes per operation by Future 2.

Major Recommendations	Annual Delay Savings			
	Future 1		Future 2	
Alternatives	**Hours**	**1992 $ M**	**Hours**	**1992 $ M**
• Extend/upgrade Runway 1L/19R to 9,800 feet	157,160	$183.65	385,160	$632.49
• Evaluate impact of terminal expansion (68 additional aircraft parking positions)	40,400	$62.55	122,940	$204.69
• Taxiway improvements to support main terminal area and Runway 1L/19R extension	44,690	$68.81	49,050	$81.46
• Extend Runway 7L/25R to 14,400 feet	1,370	$2.07	35,130	$63.42

Figure 17. Annual Delay Costs — Capacity Enhancement Alternatives

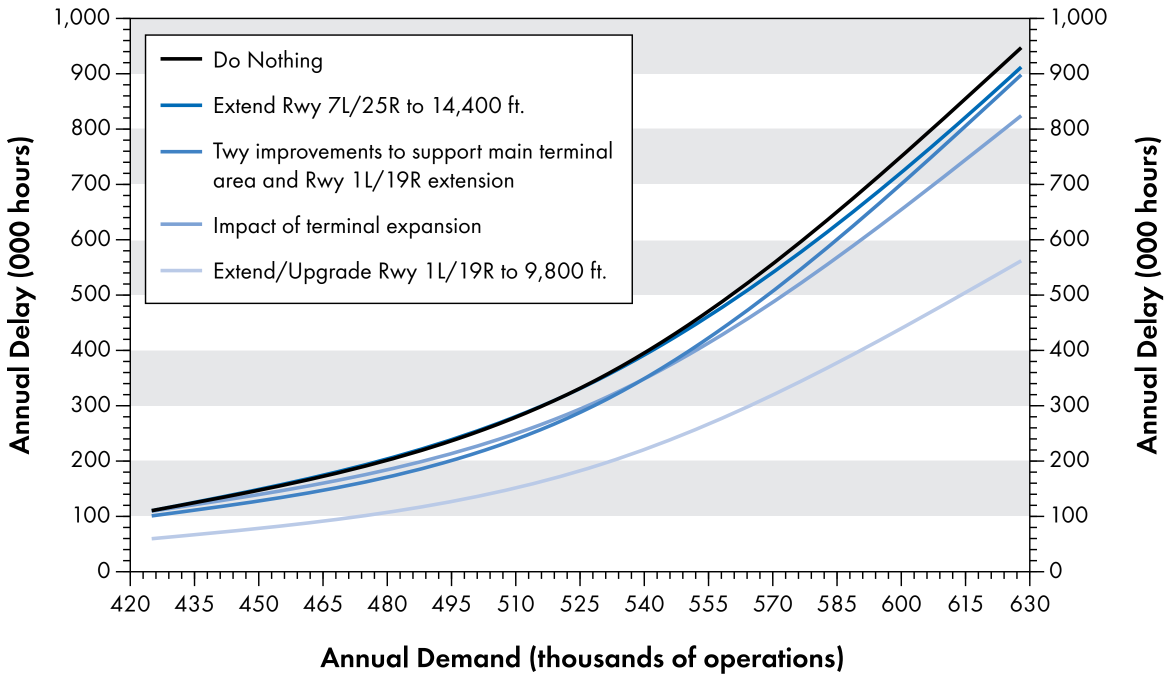
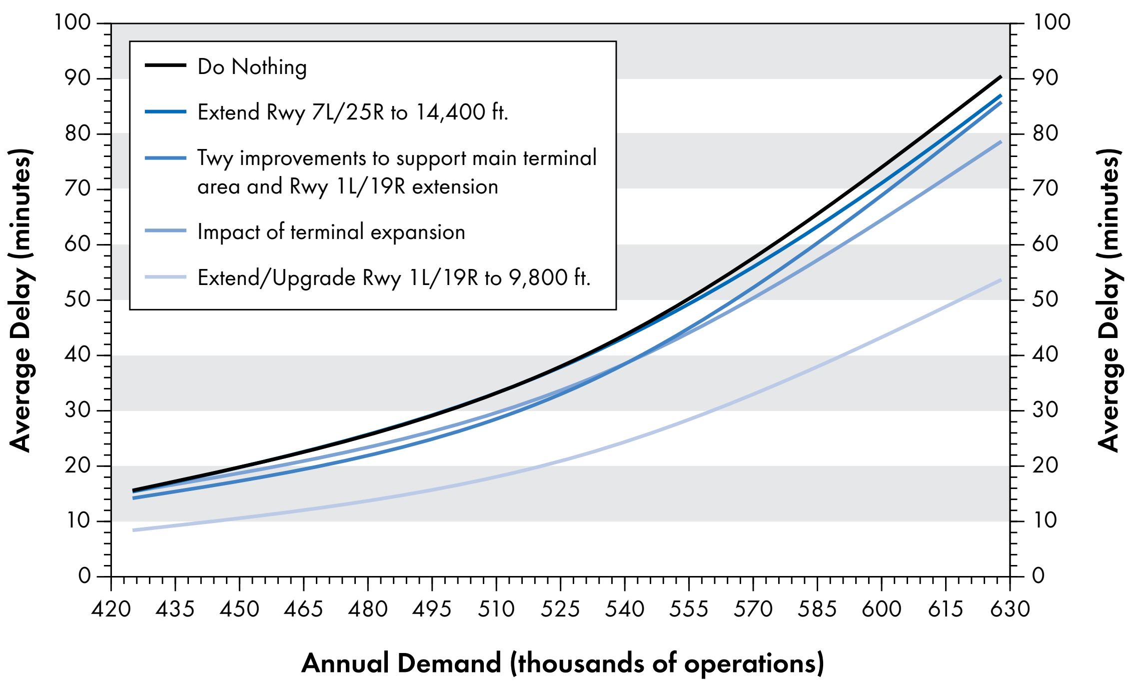


Figure 18. Average Delays — Capacity Enhancement Alternatives



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APPENDIX A

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APPENDIX B

COMPUTER MODELS AND METHODOLOGY

Computer Models

The Las Vegas Capacity Team studied the effects of various improvements proposed to reduce delay and enhance capacity. The options were evaluated considering the anticipated increase in demand. The analysis was performed using computer modeling techniques. A brief description of the model and the methodology employed follows.

Runway Delay Simulation Model (RDSIM)

RDSIM is a short version of the Airfield Delay Simulation Model (ADSIM). ADSIM is a fast-time, discrete event model that employs stochastic processes and Monte Carlo sampling techniques. It describes significant movements of aircraft on the airport and the effects of delay in the adjacent airspace. The model was validated in 1978 at Chicago O'Hare International Airport against actual flow rates and delay data.

RDSIM, on the other hand, simulates only the runways and runway exits. There are two versions of the model. The first version ignores the taxiway and gate complexes for a user-specified daily traffic demand and is used to calculate daily demand statistics. In this mode, the model replicates each experiment forty times, using Monte Carlo sampling techniques to introduce system variability, which occurs on a daily basis in actual airport operations. The results are averaged to produce output statistics. The second version also simulates the runway and runway exits only, but it creates its own demand using randomly assigned arrival and departure times. The demand created is based upon user-specified parameters. This form of the model is suitable for capacity analysis.

For this study, RDSIM was calibrated against field data collected at LAS to ensure that the model was site specific. For a given demand, the model calculated the hourly flow rate and average delay per aircraft during the full period of airport operations. Using the same aircraft mix, simulation analysts simulated different demand levels for each run to generate demand versus delay relationships.

Airport and Airspace Simulation Model (SIMMOD)

SIMMOD is a fast-time, event-step model that simulates the real-world process by which aircraft fly through air traffic controlled en route and terminal airspace and arrive and depart at airports. SIMMOD traces the movement of individual aircraft as they travel through the gate, taxiway, runway, and airspace system and detects potential violations of separations and operation procedures. It simulates the air traffic control actions required to resolve potential conflicts to insure that aircraft operate within procedural rules. Aircraft travel time, delay, and traffic statistics are computed and provided as model outputs. The model was calibrated for this study against field data collected at LAS to ensure it was site specific. Inputs for the simulation model were also derived from empirical field data. The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability. The results were then average to produce output statistics.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands for different times. To assess the benefits of proposed airfield improvements, different airfield configurations were derived from present and projected airport layouts. The projected implementation time for air traffic control procedures and system improvements determined the aircraft separations used for IFR and VFR weather simulations.

For the delay analysis, agency specialists developed traffic demands based on the Official Airline Guide, historical data, and various forecasts. Aircraft volume, mix and peaking characteristics were developed for three demand periods, Baseline, Future 1, and Future 2. The estimated annual delays for the proposed improvement options were calculated from the experimental results. These estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data.

The potential delay reductions for each improvement were assessed by comparing the annual delay estimates with the Do Nothing case.

Appendix C

Abbreviations

ADSIM	Airfield Delay Simulation Model
ARTCC	Air Route Traffic Control Center
ASC	Office of System Capacity and Requirements, FAA
ASDE	Airport Surface Detection Equipment
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
CAT	Category — of instrument landing system
FAA	Federal Aviation Administration
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LAS	McCarran International Airport, Las Vegas, Nevada
LBS	Pounds
MLS	Microwave Landing System
NM	Nautical Miles
RDSIM	Runway Delay Simulation Model
SIMMOD	Airport and Airspace Simulation Model
SM	Statute Miles
SOIR	Simultaneous Operations on Intersecting Runways
TERPS	Terminal Instrument Procedures
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Range — course information only

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