APPENDIX E

Runway Length Analysis

APPENDIX E - RUNWAY LENGTH ANALYSIS

BACKGROUND

In 1990, a master plan completed for Erie International Airport (ERI) recommended a 1,000-foot runway extension for Runway 6-24, providing a 7,500-foot runway length, plus the standard runway safety area length beyond each runway end of 1,000 feet. These improvements were designed to meet the FAA's Airport Reference Code C-III design standards and enhance safety for aircraft operations at ERI during wet or icy runway conditions. The 1990 master plan noted that the major carrier at ERI was contacted through the Air Transport Association (ATA) concerning their requirements for runway length, particularly during adverse weather. They indicated a DC-9-30 (the critical design aircraft) requires 7,500 feet for unconstrained operations on a wet or icy runway. (The existing runway pavement length is 6,505 feet.) The aircraft can operate on shorter lengths but must be off-loaded. Inadequate safety areas off the runway ends, both significantly shorter than the FAA standard of 1,000 feet, were also noted. At the Runway 6 approach end, the runway safety area extends only 100 feet before reaching Asbury Road; the runway safety area extends only 400 feet beyond the approach end of Runway 24 before reaching Powell Avenue.

The 1990 master plan and Airport Layout Plan addressed these operational and safety issues by providing a plan that extends Runway 6-24 a distance of 1,000 feet to the east; closes Powell Avenue; and tunnels Asbury Road under the extended runway safety area for Runway 6. The Airport Layout Plan was approved by the FAA in October 1990. As part of the planning process to prepare an updated Airport Master Plan, C&S Engineers, Inc., has been tasked with developing runway extension alternatives and making a recommendation for one of the alternatives. (It is noted here that several runway extension alternatives, including all of the options considered in the previous master plan, were evaluated. Issues regarding cost, maintenance, security, and drainage developed during the current Master Plan and Environmental Assessment have demonstrated that tunneling Asbury Road under the Runway Safety Area is not a feasible alternative.)

SAFETY ENHANCEMENT

The foremost benefit of an extension of Runway 6-24 is to comply with the FAA's minimum safety standards for the design aircraft (the McDonnell Douglas DC-9-30), enhancing safety for the design aircraft and other similar aircraft operating at the airport. The safety of the airport will be enhanced by bringing the runway safety areas (RSA) up to standards as required by the FAA as part of any proposed project development. Addressing the safety of automobiles travelling on Asbury Road should also be a primary issue when evaluating an extension of Runway 6-24. This hazard has been identified as a crucial issue since in recent years, two DC-9s and one GA aircraft have run off the runway end and into Asbury Road.

Any shift or extension of Runway 6-24 to the east, to meet the minimum required RSA of 1,000 feet of clear, prepared (graded) surface area beyond each runway end while maintaining the current usable runway length, or to provide additional runway length, would require Powell Avenue to be relocated. There is ancillary development to the runway

extension and road relocation that will improve safety of travelers. A new overpass to the railroad tracks will be built to replace the existing bridge, which is failing. Land acquisition will be necessary to improve the ATCT line-of-sight to the Runway 24 end. Both of these developments were proposed in the 1990 Master Plan for ERI.

ADDITIONAL SAFETY ENHANCEMENTS – VISIBILITY MINIMUMS

Landing visibility minimums can be reduced as a stand-alone project for the existing runway or the extension of Runway 24 may allow for the opportunity to reduce landing visibility minimums to ½ mile. The reduced minimums would improve the reliability of flight completion. This benefit also is appealing to commercial service providers because it reduces the numbers of cancelled flights. According to a conservative estimate made by the Airport's Air Traffic Control Tower (ATCT), approximately 12 flights a month are turned away from Erie in the winter months due to visibility problems. An updated FAA FAR Part 77 obstruction study is needed to validate known obstructions that may result with any runway extension and lowered visibility minimums. (C&S Engineers, Inc., has prepared a FAR Part 77 obstruction evaluation; the draft final report is included as Appendix H of this Master Plan document.)

DESIGN AIRCRAFT CHARACTERISTICS

The DC-9-30 was identified as the primary aircraft for runway length analysis. The characteristics of this aircraft are critical for determining the dimensional criteria and future facility requirements at ERI. The selection of the DC-9-30 as the design aircraft is based on its current and anticipated continuing use at the Airport. The performance characteristics of the design aircraft are displayed in Table E-1.

TABLE E-1
DESIGN AIRCRAFT PERFORMANCE CHARACTERISTICS

Aircraft	Aircraft Characteristics							
	Design Category	Maximum Takeoff Weight (lbs) MTOW	Maximum Zero Fuel Weight (lbs) MZFW	Operating Empty Weight (lbs) OEW	Maximum Payload (MZFW-OEW)	Passenger Capacity	Usable Fuel Capacity (lbs)	Range Nautical Miles
DC-9-30	C-III	108,000	87,000	56,855	30,145	115	24,649	Up to 1400

Source: C&S Engineers, Inc.

As noted, this runway length analysis focuses primarily on the DC-9-30, the critical design aircraft. Typical destinations considered are within a 500 to 750 nautical mile stage length, which would be the likely service area of commercial flights out of Erie International. There are many variables that affect aircraft performance on takeoff; among these are air density (determined by the airfield altitude and the ambient air temperature), humidity, runway surface condition and gradient, wind, and weight of the aircraft.

The aircraft weight includes the operating empty weight of the aircraft, the payload (cargo and/or passengers), and the weight of the fuel required for the anticipated flight. Aircraft weight is the most critical variable for obstacle clearance, for determining runway length, and also in terms of economics. Obstacle clearance issues are discussed in the alternatives section (Chapter 6) and in the current Obstruction Evaluation. Aircraft performance and economics are closely related. A reduction in payload because of a limited runway length means a corresponding reduction in revenue for the aircraft operator.

OPERATIONAL DATA

Performance characteristics and operational data for an aircraft are provided by each aircraft manufacturer. The following are operational variables that may be considered for a minimum runway length requirement analysis for a specific aircraft:

Maximum Design Takeoff Weight (MTOW): This is the maximum weight for takeoff as limited by aircraft strength and airworthiness requirements (the maximum weight at start of the takeoff run).

Operating Empty Weight (OEW): This is the weight of the aircraft structure, powerplant, and other items and equipment considered an integral part of the particular airplane configuration. OEW also includes crew and supplies necessary for full operations, excluding usable fuel and payload.

Maximum Design Zero Fuel Weight (MZFW): This is the maximum weight allowed before loading usable fuel, as limited by aircraft strength and airworthiness.

Maximum Payload: Maximum zero fuel weight minus operational empty weight.

Passenger Capacity: The maximum number of passengers specifically certified or anticipated for certification for a particular aircraft.

Usable Fuel: Fuel available for propelling the aircraft. The usable fuel capacity of the aircraft can be a limiting factor for the range and/or load.

Range: The range of an aircraft is the distance it can travel without refueling. Range varies with weight of the aircraft, payload and fuel available.

Operational requirements and patterns may differ for airlines and air cargo carriers. While passenger service is schedule-bound and weight-limited by seating capacity, air cargo carriers reported a certain flexibility. For example, they may "bulk out" an airplane before fueling and, depending on the weight of cargo to be transported, a refueling stop can be scheduled, adding an hour to the flight.

Among other operational variables that carriers must consider are fuel efficiency, speed airborne (affecting flight time and number of crew required), and carrying capacity (for payload efficiency in a specific market).

STAGE LENGTH

It should be noted that a more than 500-mile range for passenger service does not currently exist at Erie. (Charter operations, however, may go beyond the existing service area.) The stage lengths considered for this analysis are based upon the future potential for flights to hub locations such as Charlotte, North Carolina. Charlotte is a 500 nautical mile (NM) flight distance from Erie. Other destinations and stage lengths that may be considered include Erie-to-St. Louis (585 NM) and Erie-to-Atlanta (625 NM). (These flight distances reflect an "adjustment for reality" adding approximately 15% to straight line distances from city to city.)

Hub connections for popular passenger flight destinations are an important consideration for future commercial operations out of Erie. Direct flights to Florida from Erie are not considered likely at this time. However, it is worth noting that a recent market study completed by HNTB for Erie indicated that the current origin and destination (O & D) passenger load to Orlando is 19,300 passengers and to Tampa 12,700 passengers.

DC-9-30 RUNWAY LENGTH ANALYSIS

An initial analysis to determine the minimum runway length required to accommodate a DC-9-30 followed guidelines contained in FAA Advisory Circular (AC) 150/5325-4A, *Runway Length Requirements for Airport Design.* Using a software program developed for this AC, airport and runway data specific to ERI, a 1,150 statute mile (1,000 nautical mile) length of haul, and a wet and slippery runway variable were input, resulting in a recommended runway length for "airplanes of more than 60,000 pounds" of approximately 6,540 feet. Figure 1 shows a printout of the analysis. Additional program runs considered a 575 statute mile (500 nautical mile) stage length resulting in a recommended 5,420-foot runway length; 650 statute mile (565 nautical mile) stage length resulting in a recommended 5,570-foot runway length; 720 statute mile (625 nautical mile) stage length resulting in a recommended 5,710-foot runway length; and an 860 statute mile (750 nautical mile) stage length resulting in a recommended 5,990-foot runway length. The program was run for a dry pavement in each case and indicated no difference from wet and slippery for runway length required. The usefulness of this FAA software program is very limited; it is not a decision-making tool but rather a check or guide. The analysis is very rudimentary and includes only limited variables (e.g., it does not consider such factors as the load factor of the aircraft or temperatures that may be hotter than normal at an airport).

An additional analysis for the runway length requirement of the design aircraft, the DC-9-30, used aircraft performance tables for take-off that are included in Appendix 3 of FAA AC 150/5325-4A. This analysis takes into account the following factors: mean maximum temperature, airport elevation, length of haul, maximum difference in runway centerline elevations, take-off weight (including an allowance for fuel consumption based on the length of haul), payload, and flap setting.

AIRPORT AND RUNWAY DATA

Airport elevation . . . . . 733 feet
Mean daily maximum temperature of the hottest month . . . . . 80.00 F.
Maximum difference in runway centerline elevation . . . . . 2 feet
Length of haul for airplanes of more than 60,000 pounds . . . . . 1150 miles
Wet & Slippery Runways

RUNWAY LENGTHS RECOMMENDED FOR AIRPORT DESIGN

Small airplanes with approach speeds of less than 30 knots . . . 320 feet
Small airplanes with approach speeds of less than 50 knots . . . 860 feet
Small airplanes with less than 10 passenger seats
75 percent of these small airplanes . . . . . 2650 feet
95 percent of these small airplanes . . . . . 3170 feet
100 percent of these small airplanes . . . . . .3780 feet
Small airplanes with 10 or more passenger seats . . . . . .4230 feet

Large airplanes of 60,000 pounds or less
75 percent of these large airplanes at 60 percent useful load 4710 feet
75 percent of these large airplanes at 90 percent useful load 6140 feet
100 percent of these large airplanes at 60 percent useful load 5290 feet
100 percent of these large airplanes at 90 percent useful load 7810 feet

Airplanes of more than 60,000 pounds . . . . . Approximately 6540 feet

REFERENCE: Chapter 2 of AC 150/5325-4A, Runway Length Requirements for Airport Design, no Changes included.

Runway Length Analysis

Erie International Airport

Figure 1

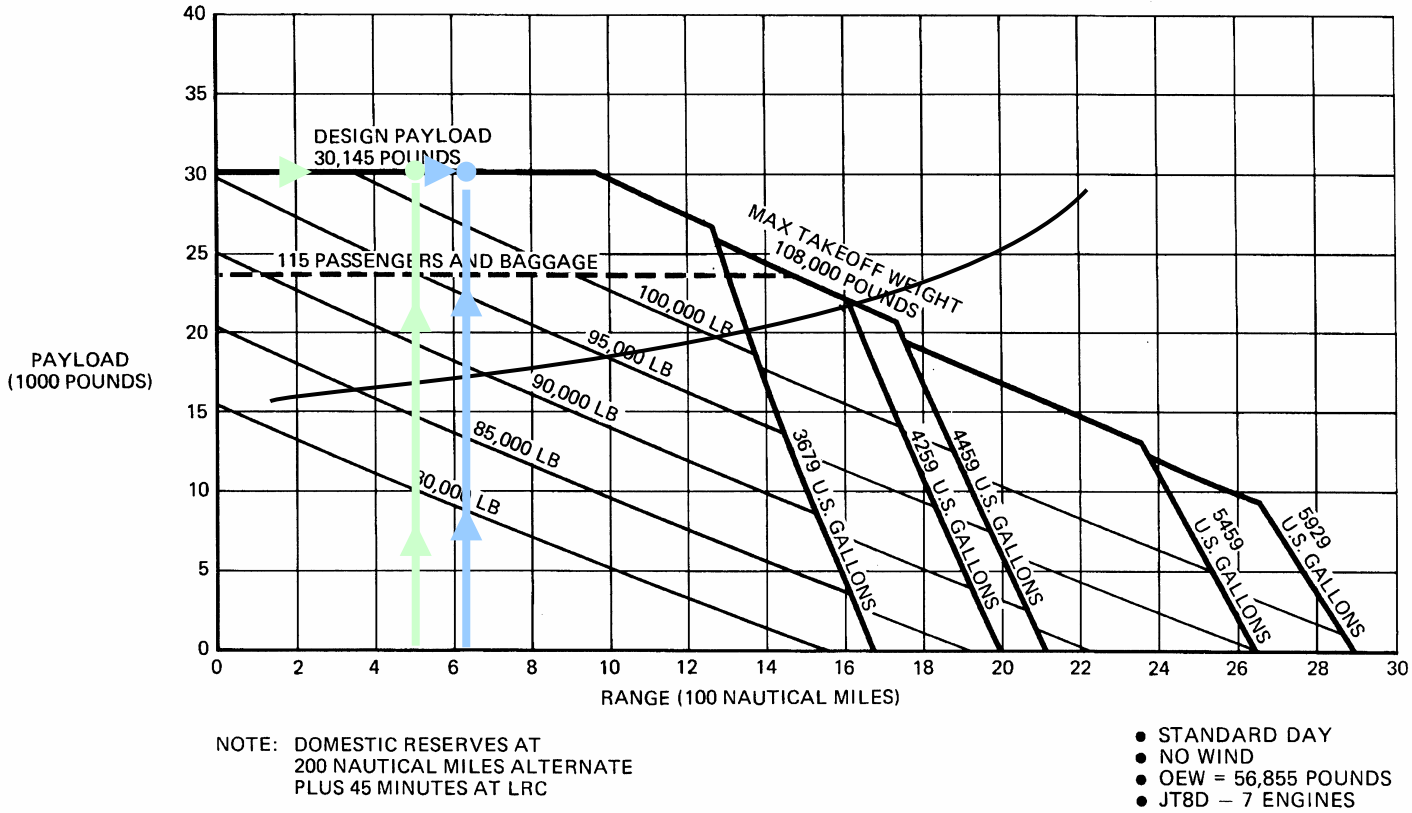
Two stage lengths were considered for this analysis, a 500 NM trip length from Erie to Charlotte, and a 625 NM trip length from Erie to Atlanta. The result of this analysis is summarized in Table E-2. The analysis demonstrates the need for a 7,204-foot runway length for a 500 NM stage length and a 7,523-foot runway for a 625 NM stage length.

TABLE E-2
DESIGN AIRCRAFT PERFORMANCE AND RUNWAY LENGTH REQUIREMENTS

Variables	Stage Length	
	500 NM (Erie to Charlotte)	**625 NM (Erie to Atlanta)**
Aircraft	DC-9-30	DC-9-30
Mean Max. Temp.	80° F	80° F
Airport Elevation	733 feet MSL	733 feet MSL
Length of Haul	500 NM	625 NM
Max. Difference in Centerline Elevation	2 feet	2 feet
Operating Empty Wt. Plus Fuel	74,620 lbs.	77,085 lbs.
Payload	30,145 lbs.	30,145 lbs.
Take Off Wt.	104,765 lbs.	107,230 lbs.
Required Take Off Runway Length	**7,204 feet**	**7,523 feet**

Sources: FAA AC 150/5325-4A, Airplane Performance Tables; C&S Engineers, Inc.

A third runway length analysis was performed for the DC-9-30, using payload/range charts and runway length curves provided by the aircraft manufacturer that incorporate the major variables defined in the previous section. Figures 2 and 3 demonstrate graphically how the payload, fuel quantity, and flight distance affect the takeoff runway length requirements for the DC-9-30. Using these resources, any number of scenarios are possible; the two scenarios considered for this analysis are typical short haul trip lengths for the DC-9-30 (500 and 625 nautical miles, the stage lengths for Erie to Charlotte and Erie to Atlanta, respectively).



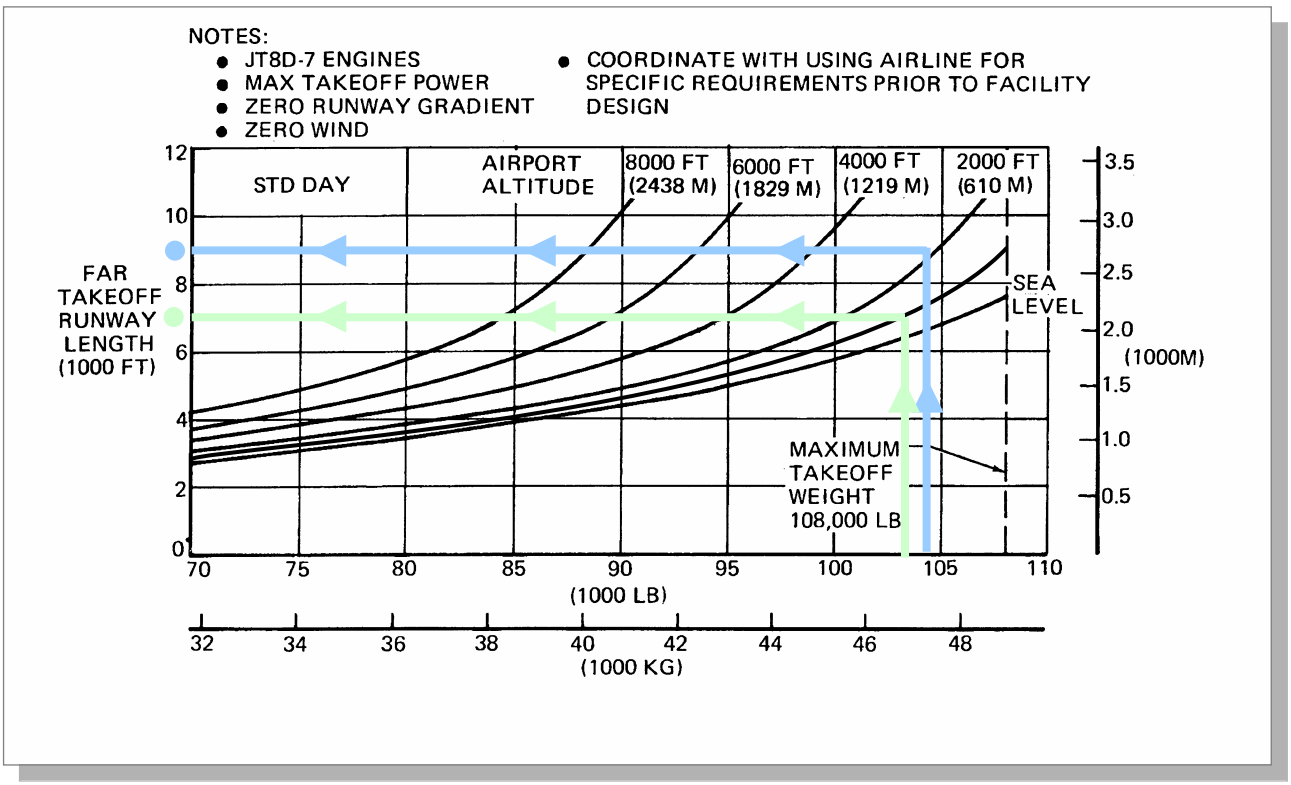
- 30,145 lbs. Payload + 500 NM = 103,000 lbs. TOW
- 30,145 lbs. Payload + 625 NM = 104,000 lbs. TOW

Source: Boeing Airplane Characteristics, Airport Planning and C&S Engineers, Inc.

Payload/Range Relationship for DC-9-30

Erie International Airport

Figure 2



Source: Boeing Airplane Characteristics, Airport Planning and C&S Engineers, Inc.

- 103,000 lbs. TOW @ 1000' Pressure Alt = 7,000' Takeoff R/W Length
- 108,000 lbs. TOW @ 1000' Pressure Alt = 9,200' Takeoff R/W Length

Takeoff Runway Length Requirements for DC-9-30 Standard Day

Erie International Airport

Figure 3

Scenario 1: A fully loaded aircraft with an operating empty weight plus payload of 87,000 pounds (an OEW of 56,855 pounds plus design pay load of 30,145 pounds) and a trip length of approximately 500 nautical miles. The takeoff weight (TOW) of the airplane would be approximately 103,000 pounds (including the fuel needed for this total aircraft weight and trip length).

Runway Length Required (DC-9-30): At standard day temperature and 1,000 feet pressure altitude, the required runway length is 7,000 feet.

Scenario 2: A fully loaded aircraft with an operating empty weight plus payload of 87,000 pounds (an operating empty weight of 56,855 pounds plus design payload of 30,145 pounds) and a trip length of approximately 625 nautical miles. The takeoff weight for the aircraft is 104,000 pounds (including the fuel needed for the total aircraft weight and trip length).

Runway Length Required (DC-9-30): At standard day temperature and 1,000 feet pressure altitude the required runway length is 7,500 feet.

SUMMARY OF RUNWAY LENGTH REQUIREMENTS

We used three methods to analyze the runway length requirements.

A runway length analysis to determine the minimum runway length required to accommodate a DC-9-30 followed guidelines contained in FAA Advisory Circular (AC) 150/5325-4A, *Runway Length Requirements for Airport Design.* Using software developed for this AC, a recommended runway length for "airplanes of more than 60,000 pounds" is approximately 6,540 feet. This analysis does not acknowledge differences between aircraft nor does it consider load factor, engine type, flap setting, wind at the airport, or other variables.

An additional analysis used aircraft performance tables for take-off that are included in Appendix 3 of FAA AC 150/5325-4A. This analysis takes into account the following factors: specific aircraft and engine, mean maximum temperature, airport elevation, length of haul, maximum difference in runway centerline elevations, take-off weight (including an allowance for fuel consumption based on the length of haul), payload, and flap setting. For the DC-9-30, this analysis recommends a runway length of 7,204 feet for a 500 NM stage length (Erie to Charlotte) and 7,523 feet for a 625 NM stage length (Erie to Atlanta).

A third analysis included payload/range charts and runway length curves provided by the aircraft manufacturer that incorporate these major variables. Based on the scenarios presented, the required runway length for the DC-9-30 is 7,000 feet for a trip length of 500 nautical miles and 7,500 feet for a 625 nautical mile trip. Table E-3 summarizes the three runway length analyses and displays the findings.

TABLE E-3
DC-9-30 RUNWAY LENGTH ANALYSIS SUMMARY

	Variables Used in Analysis	Runway Length
Analysis 1 FAA software developed for the FAA AC 150/5325-4A, Runway Length Requirements for Airport Design.	• Mean max temperature • Airport elevation • Difference in runway centerline elevations • Length of haul • Wet and slippery or dry runways (no difference) • Groups planes by weight (large planes are 60,000 lbs. or more)	500 NM: 5,420 feet 625 NM: 5,710 feet
Analysis 2 Ch. 3, Runway Length Design Based on Specific Airplanes, and Aircraft Performance Tables in FAA AC 150/5325-4A, Appendix 3.	• Specific aircraft and engine • Mean max temperature • Airport elevation • Length of haul • Difference in runway centerline elevations • Payload • Take off weight including fuel allowance • Flap setting	500 NM: 7,204 feet 625 NM: 7,523 feet
Analysis 3 Payload/Range charts and Runway Length Curves provided by the aircraft manufacturer.	• Specific aircraft and engine • Standard day temperature • 1,000 feet pressure altitude • Airport elevation • Length of haul • Payload • Take off weight including fuel allowance	500 NM: 7,000 feet 625 NM: 7,500 feet

Source: C&S Engineers, Inc.

SUMMARY AND CONCLUSION

This runway length analysis supports a purpose and need for a runway extension at Erie International Airport, Tom Ridge Field, which is based upon the following:

- Enhancing safety for operations of the design aircraft (DC-9-30)
- Compliance with FAA minimum standards for runway safety area dimensions
- Providing adequate runway length for existing and future aviation demand

- Addressing the safety of automobiles and pedestrian traffic on Asbury Road
- Addressing operational limitations (accommodating aircraft departures without weight restrictions)
- Addressing specific weather conditions at Erie (runways "contaminated" by snow and ice require an adjustment for runway length)
- Reducing visibility minimums to improve reliability of flight completion
- Coordination with regional planning (to support growth and to be consistent with development planning for the city and region)
- Enhancing the capabilities and role of ERI as a part of the National Plan of Integrated Airport Systems (NPIAS)
- Providing a higher quality of service to the public, consistent with other facility improvements.

The analysis demonstrates that operations of the design aircraft require additional runway length. For unconstrained operations (fully-loaded) and a 500 NM trip length, the DC-9-30 requires at least a 7,000-foot runway and for a 625 NM trip length, it requires a 7,500-foot runway length. The report also demonstrates that safety and reliability can be enhanced by reducing visibility minimums to ½ mile.

The following considerations are included in the alternative development phase of the Master Plan:

- Runway 6-24 to be extended to 7,500 feet
- Design aircraft to remain the DC-9-30 (Airport Reference Code C-III)
- Runway 6 and 24 safety areas to be in accordance with FAA criteria
- Navigational aids to be incorporated into the alternatives to reduce visibility minimums.

A letter from J.M. Frazier, Senior Director of Operations Support Services for USAir, written in 1990 to the Erie International Airport Director, is still relevant. Mr. Frazier states, "The one thousand-foot extension would permit allowable aircraft takeoff and landing weights to increase due to calculations based on 7500 feet of available runway length. The increase of payload lift capability is beneficial, whereas the aircraft will accommodate more passengers and cargo under certain circumstances. The extension would improve reliability in winter months, when the runway has contamination (snow, slush, etc.). As you are aware, runway contamination restricts the operating weight of an aircraft, for both landing and takeoff. This reduction of lift capability can result in reduced passengers and/or cargo capacity, and jeopardizes the quality of air transportation."

As a result of this Master Plan analysis, a 7,500-foot runway length and standard 1,000-foot runway safety area lengths beyond both runway ends are recommended to address both immediate short-term and future long-term facility requirements for the planning period for Erie International Airport, Tom Ridge Field.