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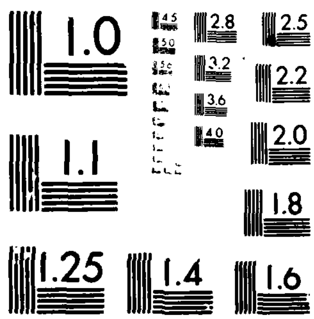

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REPORT NO. FAA-ASP-79-4

ESTABLISHMENT CRITERIA FOR RUNWAY END IDENTIFICATION LIGHTS (REIL)

November 1979

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Office of Aviation System Plans
Washington, D.C. 20591

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16. Abstract

This report develops revised establishment criteria for the Runway End Identification Light (REIL) system based on benefit/cost analysis. Three prerequisites must be met before a runway can be considered for REIL establishment: (1) Each potential candidate must not be equipped with or programmed for an approach light system; (2) Each potential candidate runway must be lighted and approved for night operations; (3) Each potential candidate runway must have a runway end identification problem resulting from such characteristics as overriding or false lights under its approach path. Runways meeting these requirements will qualify for an REIL system as follows:

1) A runway shall be a candidate when it records approximately 4900 air carrier, 1,200 air taxi (including commuter) or 7300 general aviation landings or an appropriate combination of these.

2) Runways not satisfying the numerical criteria shall be eligible for REIL when safety requirements dictate.

17. Key Words: Runway End Identification Lights, Benefit/Cost, Investment Criteria, Capital Budgeting
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EXECUTIVE SUMMARY

This report develops revised establishment criteria for the Runway End Identification Light (REIL) system based on benefit/cost analysis. Three prerequisites must be met before a runway can be considered for REIL establishment.

1. Each potential candidate runway must not be equipped with or programmed for an approach light system.

2. Each potential candidate runway must be lighted and approved for night operations.

3. Each potential candidate runway must have a runway end indentification problem.

Runways meeting these requirements will qualify for an REIL system as follows:

1. A runway that records approximately 4900 air carrier, 1,200 air taxi (including commuter) or 7300 general aviation (including military) landings, or an appropriate combination of these, is a candidate for REIL.

2. Pursuant to the provisions of Paragraph lb, Order 7031.2B, runways not meeting the numerical criteria, shall be eligible for an REIL system when safety requirements dictate. This determination shall be made by the Director of the Flight Standards Service upon the written recommendation and justification of the Regional Director.

The impact of the revised criteria will be to make it somewhat more difficult to qualify for an REIL system than under the previous criteria of 3,000 landings by any type of user.

For Fiscal Year 1978, 390 runways qualified under the new criteria, compared with 608 under the present criteria. By Fiscal Year 1988, 533 runways will qualify under the new criteria, while 758 would have qualified under the present criteria.

SECTION I - INTRODUCTION

This report develops revised establishment and discontinuance criteria for the Runway End Identification Light (REIL) system. The REIL system consists of a pair of simultaneously flashing lights located laterally on each side of the runway threshold facing the approaching aircraft. These lights provide the pilot with early, positive runway end identification as well as a certain amount of circling approach and runway alignment guidance. The system is intended for day use when visibility is below two miles and for night use. REIL may be installed on the same runway as a Visual Approach Slope Indicator but are never located on the same runway with an approach light system. They are intended for installation on runways which have conflicting or confusing lights under the approach path which might be confused with, or obscure, the runway.

To simplify application of the criteria in the field, they have been divided into two phases. Phase I criteria, described in Section III, are based upon and closely approximate the more detailed benefit/cost analysis which constitutes Phase II, described in Section V. Phase I criteria are intended for use by field personnel in selecting project candidates for submission to FAA Headquarters. Phase II criteria are then applied, using data furnished by the regions with their repsonses to the annual Call for Estimates or reprogramming requests, to determine whether or not the candidate projects are economically justified.

SECTION II - PREVIOUS REIL ESTABLISHMENT AND DISCONTINUANCE CRITERIA

Previous establishment and discontinuance criteria for REIL are defined in Airway Planning Standard Number One (APS-1) (Reference 2), dated September 20, 1974, as follows:

A. Establishment. An airport is a candidate for REIL when the runway for which it is proposed is lighted, has 3,000 or more annual landings, and a minimum safety factor of 90, in accordance with Agency Order 8260.18A (Reference 7).

B. Discontinuance. An REIL facility is a candidate for decommissioning when the number of annual landings on the runway served by the REIL is less than 2,000.

APS-1 also specifically indicates that no reduction in IFR visibility minimums will be authorized upon the installation of an REIL system.

SECTION III - REVISED REIL ESTABLISHMENT AND DISCONTINUANCE CRITERIA

The procedures developed below replace the previous criteria that are contained in Airway Planning Standard Number One and described in Section II. They are divided into two parts: Phase I and Phase II. Phase I criteria are primarily used to identify candidates for budget submissions which are submitted in response to the annual Call for Estimates. Phase II consists of a benefit/cost evaluation of candidates identified in Phase I using the techniques described in this report.

Before the evaluation of any candidate is undertaken, it must meet the following prerequisites:

- The runway must be equipped with an approved runway lighting system and available for night operations.

- The runway must not be equipped or programmed to be equipped with an approach light system.

- The runway must have a runway end identification problem which can be corrected or improved by an REIL System. These types of problems are defined in FAA Order 8260.18A, "Establishing Requirements for Visual Approach Aids" (Reference 7). Two examples of such problems are overriding and false lights. Briefly, an overriding light problem exists when a general preponderance of metropolitan or area lighting is located within two miles of the circling approach area to the runway. A false light problem exists whenever a configuration of non-aviation lighting, underlying the approach surface, presents the pilot with false runway cues. An example is a well-lighted boulevard or expressway which crosses the approach area at a 45-degree or less angle to the extended runway centerline. The determination of the existence of these types of problems is the responsibility of the Flight Standards Service.

A. Phase I Establishment Criteria

1. All Runways

Under Phase I criteria, a factor called the runway ratio value is computed by the following procedure. First, a ratio value for each user class is computed for the airport as a whole by dividing the number of landings made at the airport by that class of user by the number of landings that would qualify a runway for an REIL system if there were no landings by the other user types. The ratios for each user group are then summed to obtain the airport ratio value. This, in turn, is multiplied by the runway utilization factor (percentage of all landings accounted for by the particular runway), developed below, to obtain the runway ratio value. If the runway ratio value is equal to or greater than 1.0, the runway becomes a candidate for an REIL system. The computation procedure is illustrated below.

Air Carrier:	$\dfrac{\text{Annual Airport (AC) Landings}}{\text{Qualifying (AC) Landings}}$	=	x.xx
Air Taxi (includes commuters):	$\dfrac{\text{Annual Airport (AT) Landings}}{\text{Qualifying (AT) Landings}}$	=	x.xx
General Aviation/ Military:	$\dfrac{\text{Annual Airport (GA + Mil) Landings}}{\text{Qualifying (GA + Mil) Landings}}$	=	x.xx
	Airport Ratio Value	=	x.xx

Runway Ratio Value = Airport Ratio Value x Runway Utilization

Annual Landings - This refers to the airport's actual number of annual total landings by user class. If this traffic information is not actually recorded, estimates (as shown on FAA Form 5010-1) will be acceptable.

Qualifying Landings - These are as indicated below:

User Category	Qualifying Landings
Air Carrier (AC)	4900 (rounded from 4908)
Air Taxi (AT) (includes commuters)	1200 (rounded from 1173)
General Aviation (GA) (includes military)	7300 (rounded from 7259)

The runway utilization factor may be obtained by one of two methods. If aircraft activity is counted by runway, then the percentage use of each runway can be calculated directly, with the percentage use that applies to the REIL candidate runway used as the runway utilization factor. If the actual aircraft activity data by runway is not available, as is usually the case, the runway utilization factor may be obtained from Table 1. In the row corresponding to the number of active lighted runways at the airport, the busiest lighted runway is assumed to have the first percentage of all landings; the next busiest lighted runway is assumed to have the second percentage; and so on. After all lighted airport runways have been ranked according to activity, the percentage obtained from Table 1 for the REIL candidate runway will be used as the runway utilization factor.

TABLE 1

Runway Utilization

(for use if actual data is not available)

Number of Lighted Runways*	Busiest Runway										Least Busy Runway	
2	70	30										
4	50	25	15	10								
6	30	20	15	15	10	10						
8	30	20	15	10	10	5	5	5				
10	25	15	10	10	10	10	5	5	5	5		
12	20	15	10	10	10	5	5	5	5	5	5	5

*Number of runways refers to the ends of all active, hard-surface runways

2. Runways Not Meeting Requirements of III A(1) Above.

Pursuant to the provisions of Paragraph 1b, Order 7031.2B, a runway shall be eligible for an REIL system when exceptional safety requirements dictate. This determination shall be made by the Director of the Flight Standards Service upon special written recommendation and justification by the Regional Director. Systems established under this provision shall not be subject to Phase II, described below.

B. Discontinuance Criteria (Phase I)

To determine whether a runway meets the discontinuance criteria, the runway ratio value is calculated as described in Section III, paragraph A(1). If the runway ratio value is less than 0.5, then the runway becomes a candidate for decommissioning. The decommissioning shall first be justified by a detailed benefit/cost study. This provision does not apply to REIL systems established in response to exceptional safety requirements. Such systems shall become candidates for decommissioning when the runway ratio value is less than .5 and exceptional safety requirements no longer indicate the need for REIL.

C. Benefit/Cost Analysis (Phase II)

REIL candidate runways identified by the above criteria will be evaluated using the benefit/cost (B/C) technique described below. FAA offices, services, and regions will submit the following data required for this evaluation with their reponse to the annual Call for Estimates or with reprogramming requests.

1. Annual operations by user class (AC, AT, GA, Mil);

2. Whether an approach light system is installed or programmed for the candidate runway;

3. Runway utilization (if not available, supply number of lighted runways at airport and number of REIL already installed or programmed for other lighted runways at the same airport);

4. Fraction of time that IFR weather prevails for the proposed candidate, if available. For the purpose at hand, IFR weather will be defined as the fraction of the time that visibility is below 3 miles and the ceiling below 1,500 feet. (If this fraction is not available, the national average value will be used);

5. Fraction of landings by user class (AC, AT, GA, MIL) which occur during hours of darkness. (If this fraction is not available, the national average value will be used);

6. Statement by regional Flight Standards Division Chief certifying that a runway end identification problem which will be corrected or improved by REIL, as described in Order 8260.18A, exists for the candidate runway.

If the B/C ratio obtained from this procedure is 1.0 or greater when the life-cycle costs used include both initial investment and annual operations and maintenance (O&M) costs, the runway can be considered for the establishment of an REIL. If the B/C ratio obtained from this evaluation is less than 1.0 when the life-cycle costs used include only annual O&M costs, then the runway may be considered for decommissioning. (Installation costs are not included when an REIL is being considered for decommissioning since they are sunk costs.)

SECTION IV - REIL COSTS

REIL costs, their life-cycle counterparts, and their components are reported in Table 2. Facilities and Equipment costs consist of equipment, installation, and commissioning flight check costs, whereas operations and maintenance costs consist of annual recurring expenditures such as labor compensation and replacement parts. Life-cycle costs are calculated by discounting operations and maintenance costs to the present year and adding them to facilities and equipment costs, which are assumed to occur at the beginning of the installation year.

TABLE 2

REIL Costs

	Cost (1977 $)	10% Discount Factor	15-Year Discounted Costs
Facilities and Equipment			
Washington	$10,300		
Regional	7,400		
Total	$17,700	1.000	$17,700
Operations and Maintenance			
PCB	$1,093		
Other Objects	967		
Stocks and Stores	271		
Total	$2,331	7.606	$17,730
Total Discounted Life-Cycle Cost			$35,430

Source: Equipment - AAF-130; Maintenance - AAF-250; Stocks and stores - ALG-240

SECTION V - METHODOLOGY FOR ESTIMATING REIL SAFETY BENEFITS

The benefits provided by REIL are exclusively in the area of safety. They consist of the costs of accidents in terms of human lives, injury, aircraft damage and accident investigation costs that the system can prevent. REIL systems help prevent accidents by enabling the pilot to quickly and positively identify the runway of intended landing and its threshold. They also provide some guidance in circling approaches and runway alignment. This section details the methodology used to estimate the benefits of REIL. The methodology recognizes that REIL is a special-purpose landing aid designed for use where ground lighting conditions under the approach path, or other factors, are such that runway and runway end identification are difficult. The analysis begins by developing the average REIL-preventable accident rate for all runways. The accident rate for those runways which have runway end identification problems is then estimated based upon the average rate for all runways. Accident rates, accident costs, and forecast traffic growth are then used to estimate the benefits per landing associated with an REIL system and to calculate the qualifying number of landings, reported in Section III.

A. Average Accident Frequency for All Runways

1. REIL-Preventable Accidents

The first step in the estimation of REIL benefits is to estimate the average proportion of accidents to total landings on all non-REIL-equipped runways that could be prevented if the REIL system was installed. This requires that the number of REIL-preventable accidents over a given time period be identified and divided by the number of landings that occurred on all non-REIL-equipped runways during this time period. REIL-preventable accidents were identified by reference to the National Transportation Safety Board (NTSB) data files.

As part of its function, NTSB investigates and documents all aviation-related accidents. For each accident, the Board issues a comprehensive report containing a description of the events leading up to the accident, an account of the damage and injuries incurred, prevailing weather, a listing of probable causes and related factors, and other pertinent information. This information is summarized in the accident briefs, which are published several times each year (Reference 1). While the briefs are not as detailed as the complete reports, they do contain sufficient information to determine whether or not a particular accident might have been averted if an REIL had been installed.

To identify REIL-preventable accidents, 11,214 accident briefs filed during 1974, 1975, and the first 9 1/2 months of 1976 were reviewed. (At the time of review, the last 2 1/2 months of 1976 had not been published.) Reviewed accidents represented approximately 98 percent of all accidents which occurred, the remainder being foreign air carriers operating within the CONUS. The review was conducted separately for air carrier, air taxi (including commuters), and general aviation. Military accidents were not considered since they are not investigated by NTSB.

The purpose of the accident examination was to identify those accidents that probably would not have occurred if an operating REIL would have been present. Guidelines were developed to decide whether or not an accident was or was not REIL-preventable based on requirements for REIL systems outlined in FAA Order 8260.18A, "Establishing Requirements for Visual Approach Aids" (Reference 7). This order indicates FAA's Flight Standards Service determination of the effectiveness of REIL systems in preventing accidents. The most effective use of an REIL is in aiding rapid and positive runway identification. Secondary effectiveness is in providing runway alignment and circling guidance. The benefits can occur only when REIL systems are turned on: normally during hours of darkness and during the daytime when IFR weather prevails. Accordingly, accidents during night hours and daytime hours when IFR weather prevailed which involved overshoots, undershoots, collision with the ground on final approach, misalignment with the runway of intended landing, lost runway on a circling approach, collision with obstacles on a go-around necessitated by an overshoot, and other similar types of accidents were identified as being possibly REIL-preventable. These were subsequently selected for additional study to determine whether, in fact, the existence of an REIL could have prevented or reduced the severity of an accident. Table 3 indicates the number of accidents judged REIL-preventable over the period of study by class of user.

TABLE 3

REIL-Preventable Accidents by User Class
(1974-1976)

Air Carrier	0
Air Taxi	5
General Aviation	56

2. Accident Rates--Landings per Avertable Accident

The frequency of occurrence of REIL-preventable accidents may be measured in either of two related ways--the accident rate and the average number of landings per avertable accident. The accident rate is computed by dividing the number of REIL-preventable accidents (Table 3) by the total number of landings on runways without REIL's or approach lighting systems; landings per accident is the reciprocal of the accident rate. These measures are reported in Table 4.

The denominator of the accident rate--landings on non-REIL or non-approach light runways--is estimated in Appendix A. Briefly, the estimation procedure consists of adjusting total traffic for each user class to reflect that traffic which occurs at night and during daytime IFR conditions, subtracting out operations on ILS and REIL-equipped runways, and dividing by 2 to obtain landings.

In the case of air carriers, accident rates and landings per accident cannot be calculated directly in that no accidents occurred during the study period. Since it seems unlikely that the air carrier accident rate is zero under such circumstances, the non-occurrence of air carrier accidents over the study period probably happened by chance. Therefore, it is necessary that air carrier landings per accident be calculated indirectly. This is achieved by relating the air carrier rate to the air taxi and general aviation rates. The MITRE Corporation estimated that 54 air carrier, 287 air taxi, and 11,048 general aviation visual approach and landing accidents occurred between 1964 and 1972 (Reference 14, Table 4-1). Dividing each accident count by estimated landings during this period yields respective accident rates for each user group. Taking the ratio of the air carrier rate to both the air taxi and general aviation rates produces two separate estimates of the relative safety of air carrier approach and landing operations on non-ILS, non-REIL-equipped runways. These ratios have been used to calculate two separate estimates of air carrier accident rates and landings per accident; the average of these two estimates is reported in Table 4 for air carriers.

TABLE 4

Average Accident Rates and Landings per Accident

User	Accidents Rate (per Million Landings)	Landings per Accident
Air Carrier	.08577	11,659,088
Air Taxi	1.9531	512,007
General Aviation	2.0611	485,178

B. Accident Frequency for Runways with Runway End Identification Problems

This section develops accident rates and landings per avertable accident for those runways which have runway end identification problems, as defined above. The average accident rate for all runways, also developed above, is in effect a weighted average of runways with these problems and all other runways. This average can be expected to be larger than the rate for runways without these problems and smaller than the rate for those runways with them. Equation (1) indicates this relationship.

$$R_A = (1-\alpha)\ R_O + \alpha R_H \qquad (1)$$

Where:

R_A = average accident rate as estimated above

R_O = accident rate for all runways without runway end identification problems

R_H = accident rate for all runways with runway end identification problems

α = fraction of runways which have runway end identification problems

By rearranging terms, R_H may be expressed in terms of R_A, R_O and α:

$$R_H = \frac{R_A}{\alpha} - \frac{(1-\alpha)R_O}{\alpha} \qquad (2)$$

Then, by estimating α and making assumptions about R_O, R_H may be approximated. The fraction of runways which have runway end identification problems has been estimated by the Flight Standards Service to be .23.

By observing that R_O lies between zero and R_A, an upper and lower bound for R_H may be calculated by alternatively setting R_O to 0 and to R_A. To err on side of safety, the upper bound of R_H is selected. This rate and landings per accident--its reciprocal--are reported in Table 5.

TABLE 5

Accident Rates and Landings per Accident
for Runways with Runway End Identification Problems

User	Accident Rate (per million Landings)	Landings per Accident
Air Carrier	.37290	2,681,684
Air Taxi	8.4817	117,762
General Aviation	8.9613	111,591

C. Accident Costs

Accident costs consist of damage to aircraft, personal injury, deaths and accident investigation costs. The average expected damage to an aircraft is valued at its replacement cost multiplied by the average fraction of an aircraft--damage factor--destroyed in an accident. This damage factor is a weighted average of a total damage factor of 1, a statistically derived substantial damage factor of 1/3, and a minor damage factor of 0 (Reference 6, p. 74), where the weights are the fraction of REIL-preventable type accidents falling into each category (Reference 3, p. 44 and Reference 4, p. 28). Damage factors, average replacement values of aircraft, and average accident costs are reported in Table 6.

TABLE 6

Aircraft Accident Cost

User	Value a/	Average b/ Damage Factor	Expected Accident Cost
Air Carrier	6,000,000	.55	3,300,000
Air Taxi	200,000	.41	82,000
General Aviation	50,000	.41	20,000

a/ Cost-Benefit Analysis and the National Aviation System, FAA-AVP-77-15, February 1977, p.74.

b/ A weighted average of a total damage factor of 1, substantial damage factor of 1/3, and minor damage factor of 0. Damage factors are from Cost-Benefit Analysis and the National Aviation System, FAA-AVP-77-15, February 1977, p.74. Weights computed from data in National Transportation Safety Board, Annual Review of Aircraft Accident Data: U.S. Air Carrier Operations 1975, NTSB-ARC-77-1, p. 44 and Annual Review of Aircraft Accident Data: U.S. General Aviation Calendar Year 1975, NTSB-ARG-77-1, p. 28.

Personal injury and death costs are valued by multiplying the number of minor or serious injuries and deaths per accident by their respective costs. Human life is evaluated at $300,000 for each accident fatality, based on agency estimates from non-Warsaw accident settlement data. Minor injuries are valued at $6,000 and serious injuries at $45,000. Injury estimates are from Fromm (Reference 13) based upon an average seriously injured passenger requiring six months to fully recuperate and one with a minor injury requiring about one month to fully recuperate. Fatalities and injuries per accident from TSC estimates (Reference 8, p. A-4) are reported in Table 7.

TABLE 7

Fatalities and Injuries per Accident

User	Fatalities per Accident	Serious Injuries per Accident	Minor Injuries per Accident
Air Carrier	7.15	7.34	5.17
Air Taxi	2.0	1.3	2.0
General Aviation	.9	.6	.9

Source: Establishment Criteria for Category I Microwave Landing System (Draft), May 1978, p. A-4

Accident investigation costs for REIL preventable accidents are calculated based upon Office of Aviation System Plans estimates for NTSB and FAA accident investigation costs (Reference 5). NTSB is responsible for the investigation of all aircraft accidents. Generally, NTSB investigates all air carrier accidents and all fatal air taxi and general aviation accidents. Responsibility for non-fatal air taxi and general aviation accidents is usually delegated by NTSB to FAA. Table 8 reports NTSB and FAA investigation costs for each user type; fraction of accidents investigated by each agency (designated as "weights" in the table), and accident investigation costs by user type. The NTSB weight equals the fraction of total accidents for a user type with at least one fatality. The FAA weight equals one minus this value. Total accident costs by user type are presented in Table 9.

TABLE 8
Accident Investigation Cost
(1977 dollars)

User Type	NTSB or FAA Cost	Weights a/	Accident Investigation Cost
Air Carrier (NTSB only)	$200,772	--	$200,772
Air Taxi			
NTSB	7,114	.6	
FAA	881	.4	
Weighted Average			4,621
General Aviation			
NTSB	7,114	.32	
FAA	881	.68	
Weighted Average			2,876

a/ NTSB weight equals the fraction of total accidents with at least one fatality; FAA weight equals 1 minus NTSB weight.

TABLE 9

Accident Costs
(thousands of dollars)

User Type	(Fatalities per Accident) x $300,000	(Serious Injuries) x $45,000	(Minor Injuries per Accident) x $6,000	Aircraft Damage	Accident Investigation Cost	Total
Air Carrier	2,145	330.3	31.02	3,300.0	200.77	6,007.1
Air Taxi	600	58.5	12.00	82.0	4.62	757.1
General Aviation	270	27.0	5.40	20.5	2.88	325.8

D. Safety Benefits

Safety benefits per landing are calculated by dividing accident cost (Table 9) by the number of landings per avertable accident (Table 5). These values are reported in Table 10.

TABLE 10

Safety Benefits per Landing

User Type	Benefits
Air Carrier	$2.24
Air Taxi	6.43
General Aviation	2.92

Total benefits for the current year may be calculated by multiplying the per-landing benefit by the number of landings at any particular site during daytime IFR hours and evening hours. However, in order to evaluate the installation of an REIL system which is assumed to have a useful life of 15 years, it is necessary to calculate the present value of benefits over a 15-year period. This is accomplished by applying traffic growth rates, as estimated in the official forecasts, and the OMB prescribed 10 percent discount rate to current year safety benefits per landing. Growth rates, discount factors, their product (the discount factor), and the sum of these net factors by user type are indicated in Table 11. The present value of benefits per landing over a 15-year period is estimated by multiplying the sum of the net discount factor for each user by the current year safety benefits per landing (from Table 10). These results are reported in Table 12.

TABLE 11

Net Discount Factors

Year After Funding	10% Discount Factor	Aviation Growth Factor 1979-1993			Net Discount Factors for Benefits		
		AC	AT	GA	AC	AT	GA
1	.909	1.019	1.096	1.027	.926	.996	.934
2	.826	1.038	1.242	1.066	.857	1.026	.881
3	.751	1.058	1.339	1.107	.795	1.006	.839
4	.683	1.086	1.436	1.160	.742	.981	.803
5	.621	1.106	1.558	1.222	.687	.968	.771
6	.565	1.125	1.657	1.288	.636	.936	.737
7	.513	1.144	1.705	1.354	.587	.875	.707
8	.467	1.172	1.802	1.430	.548	.846	.676
9	.424	1.193	1.894	1.503	.506	.803	.647
10	.386	1.215	1.990	1.583	.469	.768	.610
11	.351	1.237	2.092	1.667	.434	.734	.594
12	.319	1.259	2.198	1.755	.402	.701	.568
13	.290	1.282	2.312	1.848	.372	.670	.544
14	.263	1.305	2.428	1.946	.343	.639	.519
15	.239	1.328	2.552	2.049	.317	.610	.497
	7.606				8.622	12.560	10.335

TABLE 12

Discounted 15-Year Benefits
Associated with a Landing

User Type	Benefits
Air Carrier	\$19.31
Air Taxi	80.76
General Aviation	30.18

E. Qualifying Landings

This section calculates the number of landings for each type of user that would qualify a runway for an REIL system if there were no landings made by other user types. By definition, a runway qualifies for an REIL system when the life-cycle benefits generated by the system equal or exceed the life-cycle costs of the system. To determine qualification levels, the minimum number of landings which will generate benefits equal to costs must be calculated. This is accomplished by taking the present value of the benefits of a single landing that occurs when REIL are turned on (from Table 12), reducing this value to reflect that only a fraction of the landings at an airport occur when REIL are operating, and dividing this value into the life-cycle cost of an REIL system (from Table 2). The details of these calculations are given below, and the actual calculations are presented in Table 13. Calculations are based upon national averages for incidence of IFR weather, fraction of operations occurring during hours of darkness, and life-cycle costs. In actual practice, airport specific values for these parameters will be used when they differ significantly from national averages and when they are available.

$$QL_{ac} = \frac{C}{(PVL_{ac})\ [RPD_1\lambda_4 + N_1\lambda_5]} \qquad (3)$$

$$QL_{at} = \frac{C}{(PVL_{at})\ [RBD_2\lambda_4 + N_2\lambda_5]} \qquad (4)$$

$$QL_{ga} = \frac{C}{(PVL_{ga})[RABD_3\lambda_1\gamma_1 + N_3\lambda_2\gamma_1 + N_3\lambda_3\gamma_2]} \qquad (5)$$

Where:

QL_{ac}, QL_{at}, QL_{ga}	=	qualifying landings for air carrier, air taxi, and general aviation, respectively
C	=	life-cycle cost of an REIL system (from Table 2)
PVL_{ac}, PVL_{at}, PVL_{ga}	=	present value of the life-cycle benefits of an air carrier, air taxi, and general aviation landing, respectively (from Table 11)
R	=	fraction of time weather is below 1,500-foot ceiling and visibility is less than 3 miles divided by .1348, the national average for such weather conditions; if this factor is not known, R=1
A	=	.417, the fraction of general aviation itinerant operations that are on IFR flight plans (Reference 9, Table 1B and 1C).
B	=	.09265, the fraction of the time REIL are on during the daytime, equal to the fraction of the time that visibility is below 2 miles and ceiling is below 1,000 feet (Reference 7, Table C-1)
D_1, D_2, D_3	=	fraction of air carrier, air taxi, and general aviation operations, respectively, that occur between 0700 and 1759 hours divided by their respective national average values: .657, .657, .856; if any of these factors is unknown, Di=1
N_1, N_2, N_3	=	fractions of air carrier, air taxi, and general aviation operations, respectively, that occur between 1800 and 0659 hours divided by their respective national average values: 313, .313, .144; if any of these factors is unknown, Ni=1
$\gamma 1$	=	.5455, the fraction of general aviation landings that are itinerant (Reference 9, Table 1B)
$\gamma 2$	=	.4545, the fraction of general aviation landings that are local (Reference 9, Table 1B)
$\lambda 1$	=	.837, the fraction of general aviation IFR operations occurring between 0700 and 1759 hours (Reference 13, Table 5)
$\lambda 2$	=	.15, the fraction of general aviation itinerant operations occurring between 1800 and 0659 hours (Reference 13, Table 5)

λ_3 = .137, the fraction of general aviation local operations occurring between 1800 and 0659 hours (Reference 13, Table 5)

λ_4 = .657, the fraction of air carrier operations occuring between 0700 and 1759 hours (Reference 13, Table 5)

λ_5 = .313, the fraction of air carrier operations occurring between 1800 and 0659 hours (Reference 13, Table 5)

TABLE 13

Computation of Qualifying Landings

Air Carrier

$$\frac{\$34,430}{\$19.31[(1)(.09265)(1)(.657) + (1)\ (.313)]} = 4,908$$

Air Taxi

$$\frac{\$35,430}{\$80.76[(1)(.09265)(1)(.657) + (1)\ (.313)]} = 1,173$$

General Aviation

$$\frac{\$35,430}{\$30.18[(1)(.417)(.09265)(1)(.837)(.5454)+(1)(.15)(.5454)+(1)(1.37)(.4545)]} = 7,259$$

Before proceeding, it should be noted that the level of qualifying landings for air carriers is unrealistically large. In most cases, a runway with this level of air carrier landings will probably already have qualified for an instrument landing system. This estimate is also very likely unreliable. Most air carrier landings already occur on runways which are equipped with either REIL or approach light systems, resulting in relatively few opportunities for REIL-preventable air carrier accidents to occur. As a consequence, reliable estimates cannot be derived. Nonetheless, runways with REIL-correctable safety problems which are used by air carriers and are not currently equipped with REIL may exist. Moreover, specific runways serving other user types may have exceptional REIL-correctable safety problems. To insure that such problems are properly considered, this criterion reserves the responsibility of establishing eligibility for REIL on runways with exceptional safety problems to the Director of the Flight Standards Service upon the written recommendation and justification of the Regional Director.

SECTION VI - IMPACT ANALYSIS

A. Establishment Criteria

The new criteria require fewer air taxi and more general aviation landings to qualify for REIL than the previous criteria. The impact of these revisions may be assessed by comparing the number of runways which qualify under the benefit-cost provisions of the revised criteria with the number that qualify under the old criteria. This is done in Table 14, which reports qualifiers for Fiscal Year 1978, new qualifiers for Fiscal Years 1978 through 1981 and 1982 through 1988, and total qualifiers by 1988 under both previous and revised criteria.

TABLE 14

Number of Runways Qualifying for REIL
as Determined by Previous and Revised Criteria*

	FY-78	FY-79	FY-80	FY-81	FY-82-FY-88	Total
Previous Criteria	608	18	7	13	112	758
Revised Criteria	390	16	27	5	95	533

*Additional Runways may qualify under paragraph III A(2) of this report.

As can be seen, the revised criteria, based upon benefit/cost analysis, are somewhat more restrictive than the previous guidelines. In 1978, 64 percent as many runways qualify under the revised criteria as did previously. By 1988, this will rise to about 70 percent.

Phase I and Phase II will produce identical results when national averages for life-cycle costs, incidence of IFR weather, and fraction of operations occurring at night are used in the calculations. When site-specific values are used, differences between Phase I and Phase II will develop. Differences resulting from variation in life-cycle costs are expected to be small because site-specific costs for REIL are not expected to be large. Differences in IFR weather will also have a relatively small impact. For example, should the incidence of IFR weather exceed the national average by 100 percent, the number of landings required to qualify for REIL would decline by only about 14 percent for air carriers and air taxis and 10 percent for general aviation. Deviation of site-specific values for fractions of landings occurring at night from national averages will have a larger potential effect. A 100 percent increase in the fraction of landings at night will produce a decline in qualifying landings of about 45 percent for air carrier and air taxis and 55 percent for general aviation. These effects, particularly the fraction of traffic occurring at night, indicate the importance of the regions providing site-specific data for incidence of IFR weather and fraction of operations occurring at night when these values differ substantially from national averages. (As indicated above, when this data is not available national averages will be used.)

B. Discontinuance Criteria

Revision of the discontinuance criteria will have very little impact on FAA-owned and operated REIL systems. Under the old criteria, only three sites are currently candidates for decommissioning. With the new criteria, this number rises to four. However, these few sites can be expected to decline with traffic growth. By 1988, they are estimated to number about two.

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9. Establishment Criteria for Category I Microwave Landing System (MLS), Draft Report, FAA-ASP-78-1, Federal Aviation Administration, May 1978.

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APPENDIX A

Estimation of Landings on Non-REIL-Equipped Runways

This appendix presents the procedure followed to estimate the number of general aviation and air taxi landings over the study period which might have resulted in an accident preventable by an REIL system. It is this value which is the denominator in the general aviation and air taxi accident rates developed in Section V. Since REIL-preventable accidents cannot by definition occur on a runway with an REIL system, and since approach lights associated with an ILS system accomplish, among other things, what an REIL does, our attention shall be restricted to landings which did not occur on either of these two types of runways. Moreover, since REIL's are normally operated only during hours of darkness and during daytime IFR weather, estimates of landings must be only for these periods.

A. General Aviation Landings on Non-REIL, Non-ILS Equipped Runways

Estimation of the number of general aviation landings is a three-step procedure which requires segmenting activity into daytime IFR, nighttime itinerant, and nighttime local landings. The detailed computations are discussed below.

$$L_1 = \frac{\lambda_1}{2}(AB)\left[(P_{74}-Y_{74}) + (P_{75}-Y_{75}) + \frac{285}{365}(P_{76}-Y_{76})\right] \tag{A-1}$$

$$L_2 = \frac{\lambda_2}{2}\left[(P_{74}-Y_{74}) + (P_{75}-Y_{75}) + \frac{285}{365}(P_{76}-Y_{76})\right] \tag{A-2}$$

$$L_3 = \frac{\lambda_3}{2}\left[(Q_{74}-Z_{74}) + (Q_{75}-Z_{75}) + \frac{285}{365}(Q_{76}-Z_{76})\right] \tag{A-3}$$

$$L_{ga} = L_1 + L_2 + L_3 \tag{A-4}$$

where:

L_1 = number of general aviation landings during daytime IFR conditions over the 2-year, 9 1/2-month study period

L_2 = number of general aviation itinerant landings during hours of darkness over the 2-year, 9 1/2-month study period

L_3 = number of general aviation local landings during hours of darkness over the 2-year, 9 1/2 month study period

λ_1 = fraction of general aviation IFR operations occurring between 0700 and 1759 hours (Reference 13, Table 5)

λ_2 = fraction of general aviation itinerant operations occurring between 1800 and 0659 hours (Reference 13, Table 5)

λ_3 = fraction of general aviation local operations occurring between 1800 and 0659 hours (Reference 13, Table 5)

A = .417, the fraction of general aviation itinerant operations that are on IFR flight plans (Reference 9, Tables 1B and 1C)

B = .09265, the fraction of the time REIL's are on during the daytime, equal to fraction of the time that visibility is below 2 miles and ceiling is below 1,000 feet (Reference 7, Table C-1)

P_t = itinerant general aviation operations in year t at towered and non-towered airports adjusted to remove air taxis (Reference 10, Table A-1)

Q_t = local general aviation operations in year t at towered and non-towered airports (Reference 10, Table A-1)

Y_t = number of general aviation itinerant operations on ILS- and REIL-equipped runways

Z_t = number of general aviation local operations on ILS and REIL runways

All 1976 values are adjusted by the fraction 285/365 to reflect that the study period covers only the first 9.5 months of 1976.

Equation (A-1) begins with total general aviation itinerant operations, nets out those operations occurring on ILS and REIL runways, and takes 41.7 percent of them to reflect instrument operations. The resulting value is further reduced to reflect the amount of time actual instrument conditions actually prevail and the fraction of instrument traffic that occurs during daylight hours. The resulting value is divided by 2 to obtain landings. Equation (A-2) also begins with estimated itinerant general aviation operations, takes 15 percent of them to reflect that this percentage occurs at night, and divides by 2 to reflect landings. Equation (A-3) takes local general aviation operations, reduces them to obtain the 13.7 percent occurring at night, and divides by 2 to obtain landings. Total daytime IFR landings and all night landings are summed up to obtain total landings on non-REIL, non-ILS runways. The relevant values substituted into equations (A-1) through (A-4) are indicated in Table A-1 below:

TABLE A-1

Computation of General Aviation Landings
When REIL Would Be Operating on
Non-REIL, Non-ILS Runways
(Millions)

DAYTIME IFR

$$\frac{1}{2} (.837) (.09265) (.417) (53-.34) + (55.48-.37) + \frac{285}{365} (57.5-.36) = 2.46$$

NIGHTTIME ITINERANT

$$\frac{1}{2} (.15) (53.-34) + (55.48-.37) + \frac{285}{365} (57.5-.36) = 11.43$$

NIGHTTIME LOCAL

$$\frac{1}{2} (.137) (67.9-.4) + (70.2-.44) + \frac{285}{365} (72.9-.43) = 13.28$$

Total = 27.17

B. Air Taxi Landings on Non-REIL, Non-ILS-Equipped Runways

Air taxi landings are the sum of IFR landings during daylight hours and all landings at night. These are computed as follows:

$$L_4 = \frac{1}{2}B\lambda_4\left[(R_{74}-X_{74}) + (R_{75}-X_{75}) + \frac{285}{365}(R_{76}-X_{76})\right] \quad \text{(A-5)}$$

$$L_5 = \frac{1}{2}\lambda_5\left[(R_{74}-X_{74}) + (R_{75}-X_{75}) + \frac{285}{365}(R_{76}-X_{76})\right] \quad \text{(A-6)}$$

$$L_{at} = L_4 + L_5 \quad \text{(A-7)}$$

where:

L_4 = air taxi landings during daytime IFR conditions

L_5 = air taxi landing during hours of darkness

λ_4 = fraction of air taxi operations that occur between 0659 and 1800 hours (Reference 13, Table 5)

λ_5 = fraction of total air taxi operations that occur between 1800 and 0659 hours (Reference 13, Table 5)

R_t = air taxi operations at towered and non-towered airports in year t (estimated below)

X_t = air taxi operations on ILS and REIL runways in year t

As air taxi operations are exclusively itinerant, two equations, (A-5) and (A-6), are all that is required to estimate total landings. As with general aviation landings, 1976 values are adjusted to reflect the study's span of only 9.5 months of 1976. Equation (A-5) takes total air taxi operations over the study's span, reduces them to reflect the fraction occurring during the daytime, further reduces them to reflect the proportion occurring during IFR weather when REIL's would be turned on, and then divides by 2 to yield landings. Equation (A-6) takes those operations occurring at night and divides by 2 to obtain landings. The relevant values substituted into equations (A-5) and (A-6) are reported below:

TABLE A-2

Computation of Air Taxi Landings
When REIL Would Be Operating Occurring
on Non-ILS, Non-REIL Runways
(Millions)

DAYTIME IFR

$$\frac{1}{2}\ (.09265)\ (.657)\ (6.27-1.62) + (6.72-1.73) + \frac{285}{365}\ (6.9-1.73) = \quad .416$$

NIGHTIME TOTAL

$$\frac{1}{2}\ (.313)\ (6.27-1.62) + (6.72-1.73) + \frac{285}{365}\ (6.9-1.73) = \quad \underline{2.14}$$

Total 2.56

Equations (A-5) and (A-6) require air taxi operations at both towered and non-towerd airports as inputs. These data, which are not directly available, are calculated by taking the ratio of air taxi to itinerant general aviation operations at towered airports (Reference 9, Table 1B) and then multiplying the resulting factor by itinerant general aviation operations at towered and non-towered airports. These calculations are reported in Table A-3.

TABLE A-3

Estimation of Air Taxi Activity
at Towered and Non-Towered Airports
(Millions)

	1974	1975	1976
(1) Air Taxi activity at towered airports [a]	2.582	2.752	2.977
(2) General aviation itinerant operations at towered airports [b]	23.776	24.780	26.969
(3) (1)/(2)	.10861	.11107	.11038
(4) General aviation itinerant operations at towered and non-towered airports	57.8	60.5	62.5
(5) Estimate of air taxi activity at towered and non-towered airports: (3) x (4)	6.277	6.716	6.9

a. FAA Air Traffic Activity: Fiscal Year 1977, Federal Aviation Administration, Washington, D.C., September 30, 1977, Table 1B.

b. FAA Aviation Forecasts: Fiscal Years 1978-1989, FAA-AVP-77-32, Federal Aviation Administration, September 1977.

* U. S. GOVERNMENT PRINTING OFFICE : 1980 311-586/355