Federal Aviation Administration

Missed Approach Rates

Flight Systems Laboratory
DOT-FAA-AFS-450-48

September 2008

Flight Systems Laboratory
6500 S. MacArthur Blvd.
Systems Training Building Annex, RM 217
Oklahoma City, Oklahoma 73169
Phone: (405) 954-8191

OK-08-5730

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Flight Systems Laboratory
Flight Technologies and Procedures Division
Flight Standards Service

Missed Approach Rates

Reviewed by:

9/19/2008

Stephen W. Barnes **Date**
Manager, Flight Systems Laboratory, AFS-450

Released by:

9/19/08

John W. McGraw **Date**
Manager, Flight Technologies and Procedures Division, AFS-400

September 2008

Technical Report

Technical Report Documentation Page

1. Report No. DOT-FAA-AFS-450-48	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Missed Approach Rates		**5. Report Date** September 2008
6. Author(s) Dr. Richard Greenhaw, AFS-450		**7. Performing Organization Code**
8. Performing Organization Name and Address Flight Systems Laboratory, AFS-450 6500 S. MacArthur Blvd, STB Annex, RM 217 Oklahoma City, Oklahoma 73169		**9. Type of Report and Period Covered** Technical report
10. Sponsoring Agency Name and Address Federal Aviation Administration Flight Operations Branch, AFS-410 470 L'Enfant Plaza, SW Washington DC 20024		
11. Supplementary Notes		

12. Abstract

The purpose of this study is to provide a recommended revision to the missed approach rate assumption commonly used in FAA safety studies and analyses. The assumptions used in the past (such as the CRM assumption) have been conservative due to lack of precise data. However, there are now reliable sources of data, which can be used to derive a more realistic rate estimate.

We assemble missed approach data from four independent sources to calculate an overall missed approach rate estimate based on 3,443,246 approaches over the past 10 years at more than 40 airports world wide. We also provide specific missed approach rate estimates for several major airports in the United States and Europe. And we provide missed approach rates by initiation height.

13. Key Words Missed Approach Rates, Go-arounds, Balked Landings	**14. Distribution Statement** Controlled by AFS-450
15. Security Classification of This Report Unclassified	**16. Security Classification of This Page** Unclassified

Executive Summary

The purpose of this study is to provide a recommended revision to the missed approach rate assumption commonly used in FAA safety studies and analyses. For example, the rate used in the Collision Risk Model (CRM) is 1 missed approach per 100 approaches.

The assumptions used in the past (such as the CRM assumption) have been conservative due to lack of precise data. However, there are now reliable sources of data, which can be used to derive a more realistic rate estimate.

We assemble missed approach data from four independent sources to calculate an overall missed approach rate estimate based on 3,443,246 approaches over the past 10 years at more than 40 airports world wide.

We also provide specific missed approach rate estimates for several major airports in the United States and Europe. And we provide missed approach rates by initiation height.

We recommend that a general missed approach rate of 2 missed approaches per 1000 approaches be used unless there is evidence that the rate is higher at a specific airport.

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1.0 Introduction and Background

The purpose of this study is to provide a recommended revision to the missed approach rate assumption commonly used in FAA safety studies and analyses. The assumptions used in the past (such as the CRM assumption) have been conservative due to lack of precise data. However, there are now reliable sources of data, which can be used to derive a more realistic rate estimate.

1.1 Purpose and Structure of This Document

The purpose of this study is to provide a recommended revision to the general missed approach rate assumption commonly used in FAA safety studies and analyses. For example, the rate used in the Collision Risk Model (CRM) is 1 missed approach per 100 (ILS) approaches.

1.2 Background

The missed approach rate is a parameter used in many safety analyses including those concerned with airport surface penetration (such as the OFZ penetration studies), with TERPS surface penetration, with approach obstacle collision, and with parallel approach collision.

In all such studies the rate of missed approach directly affects the resultant risk assessment. The lower the missed approach rate assumed, the lower the risk assessed.

In some cases the missed approach rate assumed has led to higher minima and to other constraints that affect airport operations.

In the case of the Collision Risk Model, the missed approach rate used in that software tool (1 per 100 approaches) contributes directly to the risk outcome.

The assumptions used in the past (typically 1 missed approach per 100 approaches) have been conservative due to lack of precise data. However, there are now reliable sources of data, which can be used to derive a more realistic rate.

1.3 Definitions

We will call a Missed Approach any maneuver conducted by a pilot when an instrument approach cannot be completed to a landing. The maneuver may be initiated either prior to, at, or after the Missed Approach Point. Therefore, a Missed Approach maneuver may be initiated at high altitude or at low altitude, but it must be initiated during an instrument approach.

This definition is consistent with that of the Airman's Information Manual (AIM) and the definitions in AC 120-29A.

The AIM defines a Missed Approach as “A maneuver conducted by a pilot when an instrument approach cannot be completed to a landing.”

And AC 120-29A defines a Missed Approach as “The flight path followed by an aircraft after discontinuation of an approach procedure and initiation of a go-around.” And continues: “Typically a ‘missed approach’ follows a published missed approach segment of an instrument approach procedure, or follows radar vectors to a missed approach point, return to landing, or diversion to an alternate.”

AC 120-29A further defines a Rejected Landing as “A discontinued landing attempt. A rejected landing typically is initiated at low altitude but prior to touchdown. If from or following an instrument approach it typically is considered to be initiated below DA(H) or MDA(H). A rejected landing may be initiated in either VMC or IMC. A rejected landing typically leads to or results in a “go around,” and if following an instrument approach, a “Missed Approach.” If related to consideration of aircraft configuration(s) or performance it is sometime referred to as a “Balked Landing.” The term “rejected landing” is used to be consistent with regulatory references such as found in 14 CFR part 121 Appendix E, and policy references as in FAA Order 8400.10.

Therefore, our definition of Missed Approach will include low altitude rejected landings if the rejected landing was initiated from an instrument approach.

1.4 Assumptions

1. Approaches in the data were instrument approaches
2. Airports, runways, and approaches in the data can be assumed to be representative of those at large commercial airports.
3. Data, although collected over the past 10 years can be assumed to be representative of current and future patterns.

2.0 Basic Missed Approach Rate Data

2.1 Chicago

These data were Continuous Data Recording (CDR) radar track data collected by the Noise Abatement Office, Chicago O'Hare International Airport. These data were collected for runway 14R between January 1998 and October 2000. Although the data do not constitute all approaches to runway 14R for that time period, they have been examined in detail in a previous study [1] and verified to be representative of approaches to that runway for that time period.

Table 2.1 ORD Runway 14R MA Rate

Total Number of Missed Approaches	124
Total Number of Approaches	58,140
Missed Approach Percent	0.21%

Table 2.1 summarizes the Chicago (ORD 14R) missed approach rate based on the data collected between January 1998 and October 2000.

2.2 Five European Airports

These data were radar track data collected by AENA (Spanish Air Navigation Services provider, ATC Airports Operations Division) and Aéroports de Paris during 2002 and 2003 at three Spanish and two French airports: Charles De Gaulle Airport [LFPG], Orly Airport [LFPO], Barcelona Airport [LEBL], Madrid Barajas Airport [LEMD], and Palma de Mallorca Airport [LEPA]. These data were used in the publication [2] ICAO Circular 301-AN/174, New Larger Aeroplanes – *Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study*. The data were used in this study to estimate the missed approach and balked landing rates for representative airports.

Table 2.2 Five European MA Rate

Total Number of Missed Approaches	2,210
Total Number of Approaches	1,173,858
Missed Approach Percent	0.19%

Table 2.2 summarizes the missed approach rate for the five European airports based on the data collected during 2002 and 2003.

2.3 Airbus (5 Airlines)

These data were Flight Operational Quality Assurance (FOQA) data collected by Airbus from five Airbus client airlines between January 2003 and December 2005 at the request of the FAA for the Airbus A380 OFZ penetration study [3]. The these data were used in that study to estimate the missed approach and balked landing rates at representative airports in Europe, Asia, and the Mideast.

Table 2.3 Five Airlines MA Rate

Total Number of Missed Approaches	169
Total Number of Approaches	106,847
Missed Approach Percent	0.16%

Table 2.3 summarizes the missed approach rate for the five airlines supplied by Airbus based on the data collected between 2003 and 2005.

2.4 Multiple United States Airports

These data were collected by Mitre CAASD for the FAA Flight Simulation Laboratory (see reference [4]) using the Aircraft Performance Evaluation Capabilities (APECS) database developed by Mitre CAASD. These data were derived from the FAA's ATALAB radar track data repository. The radar tracks were originally collected between September 3 and December 31, 2007 at 33 major airports in the United States.

These data represent all usable tracks for the runways surveyed during the data collection period. And as such is representative of the approach data for these airport runways during this period.

Table 2.4 Multiple US Airports MA Rate

Total Number of Missed Approaches	3,377
Total Number of Approaches	2,104,201
Missed Approach Percent	0.16%

Table 2.4 summarizes the missed approach rate for 33 major US airports based on the data collected in late 2007.

2.5 All Four Data Sources

Table 2.5 MA Rates for All Four Data Sources

	Chicago	5 European Airports	5 Airlines	Multiple US Airports	All 4
Total Number of Missed Approaches	124	2,210	169	3,377	5,881
Total Number of Approaches	58,140	1,173,858	106,847	2,104,401	3,443,246
Missed Approach Percent	0.21%	0.19%	0.16%	0.16%	0.17%

Table 2.5 summarizes the missed approach rates based on all four data sources collected in between 1998 and 2007. The four individual rates are relatively consistent and vary between 0.16 percent and 0.21 percent. And the overall missed approach rate is 0.17 percent, or about 1.7 missed approaches per one thousand approaches.

3.0 Missed Approaches by Initiation Height

For three of the four data sources missed approaches can be categorized by initiation height. This information is sometimes useful in risk analyses. Table 3.1 summarizes the number of missed approaches for the Chicago, Five Airlines, and 33 US Airports data sets by initiation height. The height categories vary in 100 foot increments from under 100 feet to over 400 feet.

Table 3.1 Missed Approaches by Initiation Height

Initiation Height (ft)	Chicago	5 Airlines	Multiple US Airports	All 3
< 100	4	14	157	175
100 - 200	14	22	427	463
200 - 300	19	20	602	641
300- 400	14	7	445	466
> 400	73	106	1,746	1,925
Total Number of Missed Approaches	124	169	3,377	3,670

Table 3.2 summarizes the percentage of missed approaches at each initiation height category. Overall, only 5 percent of missed approaches are initiated below 100 feet, while 52 percent are initiated above 400 feet.

Table 3.2 Percentage of Missed Approaches by Initiation Height

Initiation Height (ft)	Chicago	5 Airlines	Multiple US Airports	All 3
< 100	3%	8%	5%	5%
100 - 200	11%	13%	12%	12%
200 - 300	15%	12%	18%	17%
300- 400	11%	4%	13%	12%
> 400	59%	63%	52%	53%

4.0 Missed Approaches by Major Airport

For the multiple major US airport data and the five European airport data the missed approach rates can be categorized by airport. Table 4.1 summarizes the number and rate of missed approaches by US airport for the 33 major airports surveyed. The list is sorted alphabetically by airport identifier.

Table 4.1 Missed Approach Rates by US Airport

Airport	Number of Approaches	Number of Missed Approaches	Percent
ATL	145,697	200	0.14%
BOS	65,374	124	0.19%
BWI	29,770	9	0.03%
CLT	73,919	238	0.32%
CVG	50,645	84	0.17%
DCA	27,867	56	0.20%
DEN	96,996	104	0.11%
DFW	92,452	73	0.08%
DTW	75,649	123	0.16%
EWR	55,152	116	0.21%
FLL	45,974	102	0.22%
IAD	47,927	52	0.11%
IAH	84,082	57	0.07%
JFK	63,911	50	0.08%
LAS	70,227	91	0.13%
LAX	114,560	20	0.02%
LGA	42,091	84	0.20%
MCO	63,804	70	0.11%
MDW	41,519	73	0.18%
MEM	53,916	126	0.23%
MIA	61,654	80	0.13%
MSP	61,602	92	0.15%
ORD	157,515	304	0.19%
PDX	38,485	76	0.20%
PHL	78,222	267	0.34%
PHX	65,997	64	0.10%
PIT	26,807	43	0.16%
SAN	34,071	104	0.31%
SEA	51,573	83	0.16%
SFO	59,361	185	0.31%
SLC	50,649	120	0.24%
STL	39,675	56	0.14%
TPA	37,058	51	0.14%
Total	2,104,201	3,377	0.16%

Table 4.2 summarizes the number and rate of missed approaches by US airport for the 33 major airports surveyed, this time sorted by increasing percentage.

Table 4.2 Missed Approach Rates for 33 US Airports by Increasing Percentage

Airport	Number of Approaches	Number of Missed Approaches	Percent
LAX	114,560	20	0.02%
BWI	29,770	9	0.03%
IAH	84,082	57	0.07%
JFK	63,911	50	0.08%
DFW	92,452	73	0.08%
PHX	65,997	64	0.10%
DEN	96,996	104	0.11%
IAD	47,927	52	0.11%
MCO	63,804	70	0.11%
LAS	70,227	91	0.13%
MIA	61,654	80	0.13%
ATL	145,697	200	0.14%
TPA	37,058	51	0.14%
STL	39,675	56	0.14%
MSP	61,602	92	0.15%
PIT	26,807	43	0.16%
SEA	51,573	83	0.16%
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MEM	53,916	126	0.23%
SLC	50,649	120	0.24%
SAN	34,071	104	0.31%
SFO	59,361	185	0.31%
CLT	73,919	238	0.32%
PHL	78,222	267	0.34%
Total	2,104,201	3,377	0.16%

Table 4.3 summarizes the number and rate of missed approaches by airport and year for the 5 major European airports surveyed.

Table 4.3 Missed Approach Rates by European Airport

Airport / Year	Number of Approaches	Number of Missed Approaches	Percent
LFPG / 2003	257,475	691	0.27%
LFPO / 2003	103,248	150	0.15%
LEBL / 2002	135,268	200	0.15%
LEBL / 2003	140,275	237	0.17%
LEMD / 2002	183,727	279	0.15%
LEMD / 2003	189,173	369	0.20%
LEPA / 2002	80,305	145	0.18%
LEPA / 2003	84,387	139	0.16%
Total	1,173,858	2,210	0.19%

5.0 Analysis

The rates summarized in the tables above are based on samples. These samples appear to be representative of the overall missed approach behavior at major airports. However, since the rates are calculated from samples of approaches at the airports, and not from all approaches, recommended rates should reflect the uncertainty inherent in the sampling process.

We will adopt the approach of determining 95% confidence intervals for the rates[1], and using the upper bound of each confidence interval as a conservative estimate for the actual missed approach rate. Using this approach, the 95% confidence interval for the overall missed approach rate of 0.17% would be 0.17% ± 0.0045%. The upper bound for this confidence interval would then be 0.1745%. These bounds are very sensitive to the sample sizes (number of approaches).

Also, using this approach, the upper bounds for the 33 individual US airports and 5 European airports can be calculated. Table 5.1 gives the results for the 33 US airports And Table 5.2 gives the results for the 5 European airports.

In addition, since some studies focus on missed approaches initiated below a certain height, we have calculated rates for missed approaches by airport initiated below 400 feet[2]. We calculated this rate by multiplying the confidence interval upper bound rate by 50% since Table 3.2 shows that 50% is a conservative value for the percent of missed approaches initiated below 400 feet. Tables 5.1 and 5.2 include these rates.

Table 5.1 Missed Approach Rates for 34 US Airports with Confidence Interval Upper Bounds

Airport	Number of Approaches	Number of Missed Approaches	Percent	Confidence Interval Upper Bound	Rate for Approaches Initiated Below 400'
LAX	114,560	20	0.02%	0.03%	0.02%
BWI	29,770	9	0.03%	0.05%	0.03%
IAH	84,082	57	0.07%	0.09%	0.05%
JFK	63,911	50	0.08%	0.10%	0.05%
DFW	92,452	73	0.08%	0.10%	0.05%
PHX	65,997	64	0.10%	0.12%	0.06%
DEN	96,996	104	0.11%	0.13%	0.07%
IAD	47,927	52	0.11%	0.14%	0.07%

[1] We used a modified normal approximation to the appropriate binomial distribution to calculate the confidence intervals.

[2] The height of 400 feet is used for two reasons: it is approximately the break point for which half the missed approaches are initiated above and half below, and it is a height great enough that missed approaches initiated above it are not significant for obstacle collision risk analysis.

MCO	63,804	70	0.11%	0.14%	0.07%
LAS	70,227	91	0.13%	0.16%	0.08%
MIA	61,654	80	0.13%	0.16%	0.08%
ATL	145,697	200	0.14%	0.16%	0.08%
TPA	37,058	51	0.14%	0.18%	0.09%
STL	39,675	56	0.14%	0.18%	0.09%
MSP	61,602	92	0.15%	0.18%	0.09%
PIT	26,807	43	0.16%	0.21%	0.11%
SEA	51,573	83	0.16%	0.20%	0.10%
DTW	75,649	123	0.16%	0.19%	0.10%
CVG	50,645	84	0.17%	0.20%	0.10%
MDW	41,519	73	0.18%	0.22%	0.11%
BOS	65,374	124	0.19%	0.22%	0.11%
ORD	157,515	304	0.19%	0.22%	0.11%
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EWR	55,152	116	0.21%	0.25%	0.13%
FLL	45,974	102	0.22%	0.27%	0.14%
MEM	53,916	126	0.23%	0.28%	0.14%
SLC	50,649	120	0.24%	0.28%	0.14%
SAN	34,071	104	0.31%	0.37%	0.19%
SFO	59,361	185	0.31%	0.36%	0.18%
CLT	73,919	238	0.32%	0.36%	0.18%
PHL	78,222	267	0.34%	0.38%	0.19%
Total	2,104,201	3,377	0.16%	0.17%	0.09%

Table 5.2 Missed Approach Rates by European Airport with Confidence Interval Upper Bounds

Airport / Year	Number of Approaches	Number of Missed Approaches	Percent	Confidence Interval Upper Bound	Rate for Approaches Initiated Below 400’
LFPG / 2003	257,475	691	0.27%	0.29%	0.15%
LFPO / 2003	103,248	150	0.15%	0.17%	0.09%
LEBL / 2002	135,268	200	0.15%	0.17%	0.09%
LEBL / 2003	140,275	237	0.17%	0.19%	0.10%
LEMD / 2002	183,727	279	0.15%	0.17%	0.09%
LEMD / 2003	189,173	369	0.20%	0.22%	0.11%
LEPA / 2002	80,305	145	0.18%	0.21%	0.11%
LEPA / 2003	84,387	139	0.16%	0.20%	0.10%
Total	1,173,858	2,210	0.19%	0.20%	0.10%

6.0 Recommendations and Conclusion

We recommend that for general studies not focusing on a specific airport, a missed approach rate of 0.2% (i.e., 2 missed approaches per 1000 approaches) be used as a conservative rate. This value was calculated by rounding the upper bound 0.1745% to the nearest whole number per thousand.

We further recommend that the Collision Risk Model (CRM) be modified to incorporate the missed approach rate of 0.2% instead of the current 1.0% rate.

Additionally, we recommend that the specific missed approach rates established in the tables be used for non risk studies (e.g., air traffic control workload studies) at the published sites or 0.38% (the worst case rate with sufficient data) for other sites. If sufficient data at another specific site is gathered to obtain a rate other than 0.38%, then that newly established rate may be used.

References

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