

# **Safety Benefits of Precision vs. Non Precision Approaches**



**Howard Bregman, Gerald Dorfman, John DiLeo,  
Robert DiVito, Amy Iwata, Kara MacWilliams**

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# Problem Statement

- **Provide statistical analysis of safety benefits of conducting a precision approach (PA) versus a non precision approach (NPA).**
- **Determine whether being able to fly precision approaches may have prevented non precision approach controlled flights into terrain (CFIT).**

# Approach

- Reviewed Flight Safety Foundation study
- Searched National Transportation Safety Board (NTSB) database
- Interviewed subject matter experts

# Flight Safety Foundation Study

- **International Civil Aviation Organization (ICAO) regions for the period 1984-1993.**
- **Compared accident risk for commercial air carriers**
- **Results: NPA/PA risk ratio 5:1**

# Data Used in this Statistical Analysis

- **January 1, 1986 - December 31, 1996**
- **Uses two searches of NTSB accident database**
  - **Data extracted for *Cost-Benefit Analysis of the Wide Area Augmentation System (WAAS)* for GPS/Navigation Product Team**
  - **CAASD query on CFIT during approach**

## Basis for Estimates

User Class	Total # Approaches	# PA	# NPA	%PA	%NPA
Air Carrier	7,382,608	7,031,839	350,769	95.2%	4.8%
Air Taxi	4,807,714	3,402,464	1,405,250	70.8%	29.2%
General Aviation	13,873,624	5,988,291	7,885,333	43.2%	56.8%
<b>Total</b>	<b>26,063,946</b>	<b>16,422,594</b>	<b>9,641,352</b>	<b>63.0%</b>	<b>37.0%</b>

- These totals are those used in the *Cost-Benefit Analysis of the Wide Area Augmentation System (WAAS) for GPS/Navigation Product Team*

# Statistical Analysis

## Data from WAAS Cost Benefit Study

User Class	# Accidents PA	# Accidents NPA	Probability of Accidents on PA	Probability of Accident on NPA	NPA/PA risk ratio	p-values
Air Carrier	2	3	0.000000284	0.000008553	30:1	$3.8 \times 10^{-6}$
Air Taxi	28	36	0.000008229	0.000025618	3:1	$2.1 \times 10^{-9}$
General Aviation	132	160	0.000022043	0.000020291	0.9:1	.84
Total	162	199	0.000009864	0.000020640	2:1	0

## Data from NTSB Accident Database

User Class	# Accidents PA	# Accidents NPA	Probability of Accidents on PA	Probability of Accident on NPA	NPA/PA risk ratio	p-values
Air Carrier	7	3	0.000000995	0.000008553	9:1	$4.7 \times 10^{-4}$
Air Taxi	21	17	0.000006172	0.000012097	2:1	$3.7 \times 10^{-3}$
General Aviation	105	105	0.000017534	0.000013316	0.8:1	.99
Total	133	125	0.000008099	0.000012965	2:1	$3.8 \times 10^{-7}$

## Data from Combined Analysis

User Class	# Accidents PA	# Accidents NPA	Probability of Accidents on PA	Probability of Accident on NPA	NPA/PA risk ratio	p-values
Air Carrier	7	4	0.000000995	0.000011404	11:1	$3.24 \times 10^{-5}$
Air Taxi	32	37	0.000009405	0.000026330	2:1	$2.09 \times 10^{-8}$
General Aviation	156	189	0.000026051	0.000023969	0.9:1	.87
Total	195	230	0.000011874	0.000023856	2:1	0

P-value is a technical statistical measure used to test hypotheses:  $H_0$ : NPA=PA vs.  $H_1$ : NPA>PA

# Statistical Analysis of CFIT Data

User Class	# CFIT PA	# CFIT NPA	Probability of Accidents on PA	Probability of Accident on NPA	NPA/PA risk ratio	p-value
Air Carrier	7	3	0.000000995	0.000008553	9:1	$4.7 \times 10^{-4}$
Air Taxi	21	17	0.000006172	0.000012097	2:1	$3.7 \times 10^{-3}$
General Aviation	104	103	0.000017367	0.000013062	0.8:1	.99
Total	132	123	0.000008038	0.000012758	2:1	$7.05 \times 10^{-7}$

Calculations based on data search for CFIT in NTSB accident database.

P-value is a technical statistical measure used to test hypotheses:  $H_0$ : NPA=PA vs.  $H_1$ : NPA>PA

## CFITs potentially avoided if PA available

- **Criteria for determination included:**
  - on track for NPA but landed short or long
  - incident occurred while performing additional maneuvers required for NPA
- **Exclusion Criteria:**
  - pilot never reached final approach fix
  - mechanical failures and related events
  - pilot did not follow procedures/ATC instructions

User Class	# CFIT NPA	# Potentially avoided by PA	% Potentially Avoided
Air Carrier	3	3	100%
Air Taxi	17	9	52.9%
General Aviation	103	72	69.9%
<b>Total</b>	<b>123</b>	<b>84</b>	<b>68.3%</b>

Calculations based on data search for CFIT in NTSB accident database

# Non-Quantifiable Factors

- **Flight Safety Foundation**
- **10 people interviewed (FAA, CAASD, Industry)**
- **Many factors other than the type of approach contribute to the accident rate**
  - **Pilot: experience, training, familiarity with approach, & adherence to procedures**
  - **Weather conditions: Instrument Meteorological Conditions (IMC), or Visual Meteorological Conditions (VMC)**
  - **Equipage: aircraft, airport**
  - **Air Traffic Controllers: training, procedures, & practices**

# Summary Table

## Risk ratio of NPA accident rate vs. PA accident rate

User Class	FSF Study	CBA Data Set	NTSB Query Data	Combined Data Set	CFITs only
<b>Air Carrier</b>	5:1*	30:1	8:1	11:1	9:1
<b>Air Taxi</b>	5:1*	3:1	2:1	3:1	2:1
<b>General Aviation</b>	n/a	0.9:1	0.8:1	0.9:1	0.8:1
<b>Total</b>	n/a	2:1	2:1	2:1	2:1

\* FSF study covered commercial aviation (Air Carriers & Air Taxi) worldwide

# Conclusions

- **For the total pilot population, precision approaches are safer than non precision approaches**
  - **The same holds true for air carriers and air taxis**
  - **For general aviation there is not evidence to support the claim that precision approaches are safer**
- **68% of all CFITs may have been avoidable if a PA was available**
- **Non quantifiable factors, other than approach type, influence accident rate during approaches**

# Backups

# Definitions

- “*Non precision approach procedure* means a standard instrument approach procedure in which no electronic glide slope is provided.” (FAR §1.1)
- “*Precision approach procedure* means a standard instrument approach procedure in which an electronic glide slope is provided, such as ILS and PAR.” (FAR §1.1)
- ILS Categories:
  - Category I: 200’ min. decision height (DH), 2,400’ min. runway visual range (RVR)
  - Category II: 100’ min. DH, 1,200’ min. RVR
  - Category IIIa: No min. DH, 700’ min. RVR
  - Category IIIb: No min. DH, 150’ min. RVR
  - Category IIIc: No min. DH or RVR (i.e., 0/0) (Nolan, 1994, p. 109)

# Flight Safety Foundation - Analytical Process

- **Necessary to consider factors other than approach type that can influence the risk of an accident occurring during an approach.**
  - human factors (fatigue, pilot flying time, crew training, etc.)
  - airport variables (high terrain around airport, runway length)
  - etc.
- **Essential to understand the prevalence of those individual factors, system-wide, among commercial operators not involved in accidents.**
- **Estimate of the risk of crashing with a particular factor present was accomplished by developing a Risk Ratio (RR).**

# Flight Safety Foundation - Risk Ratio for Airport-related Risk Factors

**Risk Ratio for Airport-related Risk Factors, All ICAO Regions, Study Data Base**

Airport Related Risk Factor	Risk Ratio	95 Percent Confidence Range	Risk-factor Accidents	Risk-factor Absent Accidents	Risk-factor Movements	Risk-factor Absent Movements	Movement Ratio
<b>Nonprecision Approach</b>	5.2	3.9-6.9	27	35	1,037,947	11,403,061	11.0
<b>No TAR</b>	3.1	2.4-4.0	42	89	1,322,944	11,429,765	8.6
<b>High Terrain</b>	1.2*	0.9-1.6	37	94	2,852,450	9,588,652	3.4
<b>No STAR</b>	1.6	1.2-2.1	34	97	2,122,025	10,630,685	5.0
<b>No ATIS/VOLMET</b>	3.9	2.8-5.5	28	103	693,875	12,058,835	17.4
<b>No Approach Lights</b>	1.4	1.0-2.0	23	58	2,559,278	10,191,932	4.0
<b>No VASI/PARI</b>	0.8*	0.6-1.1	32	61	5,294,677	7,458,033	1.4

\*Denotes that the risk ratio (RR) value was not statistically significant at the 5 percent level.

ICAO = International Civil Aviation Organization

STAR = Standard Terminal Arrival Route

TAR = Terminal Approach Radar

ATIS = Automatic Terminal Information System

PAPI = Precision Approach Path Indicator

VASI = Visual Approach Slope Indicator

VOLMET = Meteorology Information for Aircraft in Flight

Risks Ratio =  $\frac{\# \text{ of NPAs}}{\text{total} \# \text{ accidents}}$

$\frac{\# \text{ NPA}}{\text{total} \# \text{ approaches}}$

Source: Flight Safety Foundation, March 1996

# Flight Safety Foundation - Risk Ratio for Non precision Approaches

**Risk Ratio for Non precision Approaches, Stratified by ICAO Region**

ICAO Region	Risk Ratio	95 Percent Confidence Range	Precision Approach Accidents	Nonprecision Approach Accidents	Precision Approach Movements	Nonprecision Approach Movements	Movement Ratio
All Regions	5.2	3.9-6.9	35	27	11,403,061	1,037,947	11.0
Africa	3.6	2.1-41.7	3	5	438,193	92,031	4.8
Eastern Europe	n/a	n/a	2	0	222,743	20,080	11.1
Asia-Pacific	7.7	4.5-13.1	3	5	938,480	83,062	11.3
Europe	4.1	1.8-9.8	13	4	2,552,976	153,408	16.6
Middle East	n/a	n/a	1	0	235,666	22,730	10.4
Latin America	3.0	2.0-4.4	3	7	765,238	236,313	3.2
North America	5.8	3.0-11.0	10	6	6,249,763	430,321	14.5

ICAO = International Civil Aviation Organization

Risk Ratio (RR) values for Eastern Europe and Middle East were not included in this listing because they did not have any non precision approach accidents that were identified in the study. They were included in the aggregate calculation for all regions.

Source: Flight Safety Foundation, March 1996