CAASD

An Evaluation of Accidents Involving Nonprecision Approach

MITRE

Walter C. Scales, David A. Domino, Dr. Gerald A. Dorfman,
G. William Flathers (consultant), Kara J. MacWilliams,
Dr. S. Vincent Massimini, and Doyle Peed

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Objectives

- **Evaluate the degree to which having a precision approach (PA) is a safety benefit (relative to nonprecision approach (NPA))**
- **Develop a qualitative understanding of what is going wrong in Controlled Flight Into Terrain (CFIT) accidents related to NPA**

Background

- **Seven previous studies on NPA vs. PA safety:**

  1. **"Airport Safety: A Study of Accidents and Available Approach-and-Landing Aids," Flight Safety Foundation, March 1996**
  2. **"Analysis of Critical Factors During Approach and Landing in Accidents and Normal Flight," Final Report, Flight Safety Foundation Approach-and-Landing Accident Reduction Task Force, Data Acquisition and Analysis Working Group, 1998**
  3. **Final Report, Flight Safety Foundation Approach-and-Landing Accident Reduction Task Force, Aircraft Equipment Working Group, 1998**

Background (Concluded)

4. "An Analysis of Controlled-Flight-into-Terrain Accidents of Commercial Operators, 1988 through 1994," R. Khatwa and A.L.C. Roelen, National Aerospace Laboratory (NLR), Netherlands, 1998
5. "Safety Benefits of Precision vs. Nonprecision Approaches," MITRE/CAASD briefing, 22 September 1997
6. "General Aviation Controlled Flight into Terrain," (final draft), Joint Safety Analysis Team, April 1999
7. "CFIT Accidents on Precision and Nonprecision Approach: Potential Safety Benefits for WAAS/LAAS," MITRE/CAASD Briefing, 3 August 1999

General Conclusions to Date (Based on Statistical Studies)

- **For air carriers, PA is significantly safer than NPA, both on a worldwide basis and for North America[1]**
  - **Relative risk is roughly 6:1 or greater for North America**
  - **However, only ~5% of the US instrument approaches executed are NPAs**
- **For air taxi operations in the United States, PA is significantly safer than NPA**
  - **Relative risk of NPA over PA is ~ 3:1**
  - **About 29% of the instrument approaches are NPAs**
- **For GA operations in the United States, there are fewer studies; the overall statistics for PA over NPA do not seem compelling; Reference 7 suggests that some GA accidents would be averted if PA were widely available**

1. Includes the US, Canada, and the Caribbean

Comparison of Previous Studies and Results

Reference	Time Span	Types of Operation	Types of Aircraft	Geographic Domain	Phase(s) of Flight	Severity Criterion	Basic Conclusion(s)
1 [FSF]	1984-1993	Commercial (carriers, taxi, freight)	Fixed wing	Worldwide (by ICAO region)	Approach and landing	Loss of hull (aircraft destroyed)	NPA has ~ 5 times the risk of PA
2 [FSF, DAAWG, UK CAA]	1980-1996	Civil aviation	Fixed wing turbine >12,500 lbs.	Worldwide (by ICAO region)	Approach and landing	Fatal	NPA has 3 to 8 times the risk of PA
3 [FSF, AEWG]	N/A	N/A	N/A	N/A	Approach and landing	N/A	Minimize or eliminate IAPs w/o vertical path guidance. Provide LAAS.
4 [NLR]	1988-1994	Transport, positioning ops.	Fixed wing	worldwide	All (CFIT)	Fatal	~70% of CFIT occurred during approach/landing phase; ~60% of these were on NPAs.
5 [CAASD]	1986-1996	Air carrier, air taxi, GA (separately)	Fixed wing	US	Instrument Approach	Accident	NPA riskier than PA for air carrier and air taxi. Difference not significant for GA
6 [JSAT]	1993-1994	Part 91, 125, 133, 135, 137	All	US	All (CFIT)	Accident	Only 29% of CFIT occurred on approach (36% approach/landing).

Limitations of the August 3 “Short Fuse” Evaluation (Reference 7)

- **Less than one week was available for entire evaluation, beginning to end**
- **20 accidents reviewed by 3 evaluators**
  - **Selected as most likely candidates**
  - **Assumed that other accidents were unlikely candidates**
- **Insufficient time for data analysis (e.g., how good were the estimates?)**
- **Ex post facto analysis suggests that there was a ~ 38% chance that the observed number of agreements between evaluators would have resulted from tossing a coin**

Methodology for the Current Evaluation

- **Four experienced pilots individually evaluated each of 131 CFIT accidents related to NPA over the 1986–1998 time frame, based on NTSB data**
  - **For each accident, each evaluator decided whether, by the availability of a PA, it was more probable that:**
    - **The accident WOULD have been averted, or,**
    - **The accident would NOT have been averted**
  - **An “insufficient information” option was also provided**
  - **For each accident, each evaluator provided a confidence score ranging from 0 through 10, where 0 represented no confidence and 10 represented absolute certainty**

Methodology (Continued)

- **A confidence score of 0 was defined as equivalent to "insufficient information", i.e., toss a coin, my answer isn't valid, I really can't tell**
- **Evaluators were provided with a one-page, high-level overview of WAAS approaches. In order to simplify the evaluation, the following assumptions were made:**
  - **The hypothesized PAs would all have 200-ft decision heights**
  - **Evaluators were free to postulate the unlimited availability of PAs wherever they judged them helpful**

Methodology (Concluded)

  - The WAAS feature of interest was the availability of vertical guidance (improved horizontal guidance and situational awareness could be provided by GPS)

- This was an expert opinion study based on NTSB data. In many cases, the available data were limited, e.g., weather at the time and place of the accident was often not available. In such cases, it can be very difficult to determine with any confidence whether a PA would have averted the accident. Even with good information, the judgment can sometimes be difficult. Individual cases can often be argued one way or another.

Evaluator Qualifications

- **Evaluator 1: Airline Transport Pilot Certificate, ~3,500 hours**
- **Evaluator 2: Airline Transport Pilot Certificate (multiple type ratings), Certified Flight Instructor—Instrument, Captain and Line Route Instructor— B737, Flight Engineer, Ground Instructor, ~12,000 hours**
- **Evaluator 3: Commercial (single/multi) Airplane, Instrument, Commercial Helicopter, Ground Instructor, ~2000 hours**

Qualifications (Concluded)

- **Evaluator 4: Airline Transport Pilot (multiple type ratings), Flight Engineer, Certified Flight Instructor—Instrument, Part 121 simulator instructor and line-check airman, ~12,000 hours.**

Types of Operation in the Accident Database

- **107 General Aviation (Part 91) accidents**
- **20 Air Taxi/Commuter (Part 135) accidents**
- **4 Air Carrier (Part 121) accidents**
- **All CFIT involving NPA**
- **Time frame: 1986–1998**

Data Analysis

- **Method 1: N= $(4*n_4 + 3*n_3 + 2*n_2 + 1*n_1)/4$**
  - **where n_i is the number of accidents in which i evaluators agreed the accident would probably be averted**
  - **Ignores confidence scores, implies the probability of averting an accident is proportional to the number of evaluators who think it probably would have been averted; implies any evaluator can be wrong but all 4 evaluators can't be wrong (in either direction)**
- **Method 2: Majority vote on each accident**
  - **N= $n_4 + n_3 + n_2/2$**
  - **Break ties by allocating 50% of the accident**
  - **Ignores confidence scores, implies any evaluator can be wrong but 3 out of 4 evaluators can't be wrong (in either direction)**

Data Analysis (Concluded)

- **Method 3: Confidence-based probabilities**
  - **P[accident averted] = 0.5 + ccs/20, where ccs = coded confidence score = + confidence score if answer was "yes", - confidence score if answer was "no"**
  - **Implies each confidence score is linearly related to the true probability that the accident would have been averted (evaluators can be wrong about their yes/no answer, but are assumed to be perfect with respect to their respective confidence scores)**
  - **Implies an underlying P = 0.5 if evaluator has zero confidence in his answer**
  - **Probabilities applied uniformly over evaluators and over accidents**

Overview of Results

- **Total NPA accidents evaluated = 131**
- **Number of accidents where all evaluators agreed on probable outcome[2] with PA = 42**
- **Probability of 42 or more agreements with random binary inputs ~ 4.2×10^{-9}**
- **Total number of accidents (number per year, percent of total) estimated to be averted:**
  - **Method 1: 67 (average = 5.7 per year = 51%)**
  - **Method 2: 64 (average = 5.5 per year = 49%)**
  - **Method 3: 61 (average = 5.2 per year = 47%)**
- **95% confidence interval on Method 1: 56 to 78 (4.8 to 6.7 per year = 43% to 59%)**

[2] All evaluators agreed that the accident probably **would have** been averted, or all agreed that it probably **would not have** been averted.

Results for Part 91 Accidents

- **Total NPA accidents evaluated = 107**
- **Number of accidents where all evaluators agreed on probable outcome with PA = 34**
- **Probability of 34 or more agreements with random binary inputs ~1.5 x 10^{-7}**
- **Number of accidents (number per year, percent of total) estimated to be averted:**
  - **Method 1: 53.5 (average = 4.6 per year = 50%)**
  - **Method 2: 51.5 (average = 4.4 per year = 48%)**
  - **Method 3: 49 (average = 4.2 per year = 46%)**
- **95% confidence interval on Method 1: 43 to 64 (3.7 to 5.5 per year = 40% to 60%)**

Results for Part 135 Accidents

- **Total NPA accidents evaluated = 20**
- **Number of accidents where all evaluators agreed on probable outcome with PA = 5**
- **Probability of 5 or more agreements with random binary inputs ~ 0.095**
- **Number of accidents (number per year, percent of total) estimated to be averted:**
  - **Method 1: 10 (average = 0.85 per year = 50%)**
  - **Method 2: 9.5 (average = 0.81 per year = 47%)**
  - **Method 3: 9 (average = 0.77 per year = 45%)**
- **95% confidence interval on Method 1: 6 to 14 (0.51 to 1.2 per year = 30% to 70%)**

Results for Part 121 Accidents

- **Total NPA accidents evaluated = 4**
- **Number of accidents where all evaluators agreed on probable outcome with PA = 3**
- **Probability of 3 or more agreements with random binary inputs ~0.007**
- **Number of accidents (number per year, percent of total) estimated to be averted:**
  - **Method 1: 3.25 (average = 0.28 per year = 81%)**
  - **Method 2: 3 (average = 0.26 per year = 75%)**
  - **Method 3: 2.9 (average = 0.25 per year = 72%)**
- **95% confidence interval on Method 1: 2 to 4 (0.17 to 0.34 per year = 50% to 100%)**

Potential Database Issues

- **Did the database include all NPA CFIT accidents over the 13-year time frame?**
  - **In some cases, it can be difficult to judge whether loss of control was involved. In other cases, it can be difficult to tell whether an NPA was involved (e.g., localizer vs full ILS approach). There is some opportunity for error**
- **"Per year" accident rates include an adjustment to account for the fact that the 1997–1998 data were incomplete**
  - **These two years only contain ~0.7 years equivalent data**
  - **The accident trend over the database period was downward, with an average decrease of ~0.85 accidents per year**

Other Issues

- Impact of assumptions (factors that could reduce the safety benefit)
  - Future availability of PA where postulated (universal availability unlikely)
  - 200 ft DH (unlikely to be achieved on all WAAS PAs)
- Potential reduction of VFR into IMC accidents? (not addressed, could increase safety benefit)
- It is entirely possible that widespread availability of PA at small airports could increase the number of approaches being attempted in bad weather and at night, resulting in an unchanged or even HIGHER overall accident rate (negative safety benefit); it was not possible to assess this effect.

...and Finally

- **Standardization of approaches and increased general aviation usage of precision approaches may decrease the accident rate for precision approaches (not addressed in this effort).**