The Myth of the Unstable Approach

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Author Biography:
Dr. Wischmeyer has 6 years experience in direct flight safety research, 5 years experience developing advanced FOQA systems, and 20 years software and user interface development experience. He has flown nearly 150 makes and models of light aircraft, including the P-51, and has flown simulators for current production Boeing aircraft. He also has observed 50 airline flights from the jump seat.

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Introduction

Forty years ago, the term “pilot error” was commonly used in accident taxonomy. Eventually it was realized that this term, while technically correct, did little to explain accident causes or prevent recurrences. “Pilot error” then became an invitation to more deeply explore, to more carefully classify, and to eventually articulate and address the underlying phenomena. The generalization “pilot error” is now largely replaced by more concise, more useful, and more well understood concepts. The term “unstable approach” is now ready to begin that same evolution, and is an invitation to new discovery.

This paper begins by exploring a number of interesting parallels between “unstable approaches” and “pilot error.” Next, multiple independent sources demonstrate that almost no unstable approaches end catastrophically, and thus, it is inappropriate to consider “unstable approach” as a causal factor. Rather, “unstable approach” is almost always correctable, and/or a symptom of other phenomena. Lastly, a number of concepts and ideas are explored which are first attempts to accept that invitation to more deeply explore, more carefully classify, and finally address the underlying phenomenon. These concepts and ideas may have value in seeding new taxonomies and techniques for accident and incident analysis.

Parallels Between “Pilot Error” & “Unstable Approach”

Consider the following points of similarity between the “pilot error” concept of the 60’s with the contemporary “unstable approach” concept:

	“Pilot Error”	“Unstable Approach”
Definition succinctly defines what occurred?	No, inclusive definition	No, inclusive definition – Flight Safety Foundation’s definition has 9 elements
Is an occurrence operationally acceptable?	No	No
Occurrence increases risk?	Yes	Yes
Happens all the time?	Yes	Yes (discussed below)
Is a premeditated pilot action?	No	Not always
Have to recover from it?	Yes	Yes
Pilots almost always get away with it?	Yes	Yes
Sounds good on television?	Yes	Yes
Usually a symptom of other factor(s)?	Yes	Yes
Indicates need to find those other factors?	Yes	Yes
Gave rise to a number of valuable studies?	Yes: CRM, fatigue, human factors	Not yet…
Concept is still used for accident analysis?	No	Starting to fade

No one doubts the operational benefit of a stable approach, just as no one doubts that aircrew should not commit “pilot errors” – the issue is the value of the term “unstable approach” in safety analysis. Just because pilots should not make “unstable” approaches does not mean that this vague generalization is appropriately used in accident and incident analysis.

Prevalence of Unstable Approaches & Research History

A number of diverse, independent sources all indicate that while unstable approaches may increase the risk of a bad landing outcome, that risk is still so low that the concept “unstable approach” can only rarely, if ever, be meaningfully be used in accident and incident causal analysis.

The research on the prevalence of unstable approaches was performed at Boeing Commercial Airplane Group in 2001. My initial position was that unstable approaches were a direct cause of landing accidents, and that providing an unstable approach alert would directly and immediately reduce accidents. Thus, the researcher’s initial bias was in direct opposition to the final result. In fact, this unstable approach research was initially done strictly pro forma, as we all knew the “correct” outcome already.

The first data set examined was from NASA Aviation Safety Reporting System reports. Although it is well known that meaningful rate of occurrence statistics cannot be generated from voluntarily submitted reports, this does not mean that no meaningful statistical analyses can be performed. Rather, the analysis performed had two parts:

1. Determining what the motivating event was for each report submission. For example, an unstable approach would be a motivating event, but landing at O’Hare would not be considered motivating.
2. From sets of reports with the same motivating event, meaningful conditional probabilities could be generated with the condition being the presence of that motivating event.

Because I had the experience of working in the NASA ASRS office for several years, including performing the final check on several hundred reports before they were entered into the ASRS database, I was confident of my ability to determine motivating events and the integrity of the reports.

Reports were analyzed both where unstable approaches were the motivating event, and in which unstable approaches were significant features of the narrative. Similarly, reports were chosen where the motivating event was a landing outcome unacceptable to the flight crew. Approach instability was tabulated by the altitude (if any) at which the approach became stable, and similarly, the altitude at which the approach became unstable.

The results of these analyses were that bad landings (the motivating event) were frequently observed from stable approaches, and good landings were frequently observed from unstable approaches – and these initial, poorly understood observations were unsettling. These results also brought to mind a sampling theorem from quality control which states that, in effect, if you are expecting a phenomenon to be rare (such as good landings from unstable approaches), but a small initial sample shows a high rate of occurrence (many good landings from unstable approaches in a small, initial sample set), then you can reject the hypothesis of rarity without further sampling.

The next step was to seek quantitative verification from FOQA data. A carefully worded email to a David Wright in the CAA, who had access to large quantities of FOQA data, cautiously breached the possibility that approach parameters and touchdown parameters might not be well correlated. A few days later, a return email said, in effect, “our data shows that, too, and we don’t believe it either.”

With quantitative verification in hand, it was time to generate plausible hypotheses to explain the unanticipated results. Three were prominent:

- Because the commonly accepted high correlation between unstable approaches and bad landing outcomes was generated from accident data only, that high correlation was a result of sampling bias, in the epidemiological sense.
- There is some other phenomenon present that is tentatively named “pilot involvement factor.” This hypothesized factor states that if the pilot was flying was highly involved in flight path control, then appropriate skill and experience would be applied and the landing outcome would be successful regardless of approach stability. Conversely, if the pilot were inattentive or not completely in the loop, this state of low involvement could manifest itself in a bad landing outcome, regardless of the approach stability.
- Because many of the definitions of approach stability called for a go around by at least 500 feet (150 meters) HAT (height above touchdown) if the approach was not stable, those definitions effectively ended at 500 feet. Yet, ASRS data (and later, accident and incident data) indicated that significant atmospheric effects would be encountered at 300 feet (100 meters) HAT and below. The perturbations caused by these low level atmospheric effects would affect landing outcome statistics but would be encountered regardless of approach stability.

All of these hypotheses were discussed with peers, colleagues, management, and company pilots. None of these hypotheses were widely accepted, perhaps because the underlying premise was contrarian. More significantly, there were no successful or even substantive challenges to these hypotheses.

A number of additional quantitative sources provided privileged information. Highlights of that privileged information include:

- Three independent sources of airline approach data, with no overlap of airlines sampled, report that the rates of occurrence of unstable approaches for each of these sources were 1.6%, 3%, and 15%.
- Data from one of these sources show that, for runway overruns, a stable approach is 60 times safer than an unstable approach, and a chi-square test shows this result is statistically highly significant. On the other hand, this same data shows that if an unstable approach is used as a criterion to predict a runway overrun, it will give a false alarm 49,999 times out of 50,000.
- Data from one of these sources show that statistics generated on approach are very poorly correlated with statistics generated on landing, if at all. For some approach measurements, grouping that approach measurement would also group some landing parameters, but the distributions of those landing parameter groups overlapped so much that touchdown measurements could not be used to determine approach parameter measurements.

With ASRS and these three other sources all giving consistent results, and with plausible analysis to explain the observed results, it can be reasonably concluded that unstable approaches do not usably predict bad landing outcomes.

My management approved these results, and then asked – you’ve shown what can’t be done, now show what can be done.

Ideas for Future Analysis Directions

Just as “pilot error” opened the doors to further research that brought into prominence human factors, fatigue, and CRM, “unstable approach” can and should open the doors for the safety community to identify new areas of study. The unstable approach research done to date suggests these interesting starting points for these new flight safety theories, or support for theories already under development:

- Five sub-phases to replace “approach and landing”
- Severity-last event taxonomy
- Guidance vs. Judgment
- Outcome taxonomy to replace “approach and landing” “accident” and “incident”
- Unstable approach as a symptom

Five sub-phases to replace "approach and landing"

Analysis of accident, incidents, and events suggests that the superficially convenient temporal grouping "approach and landing" in fact groups flight sub-phases with greatly differing characteristics.

The five sub-phases are listed below in reverse chronological order. The goal of each sub-phase is to position the aircraft so that the subsequent sub-phase can be successfully completed (except the last sub-phase, of course.)

Flight Sub-Phase	Goal	Comments
Rollout and turnoff	Decelerate from touchdown speed, then transition to taxiing on the airport	
Flare and touchdown	Touchdown on runway within safety and comfort parameters, with room for rollout and touchdown	
Final visual alignment	Position the airplane visually for start of flare.	In Cat III, this phase does not appear. On a visual approach, this phase may be lengthy.
Inside the final approach fix	Maneuver the airplane so that when visual contact is established, the flight crew can manually fly the airplane to a successful landing.	
Outside the final approach fix	Maneuver to cross the FAF at an acceptable speed and altitude	Crossing the final approach fix with excessive energy is common

"Unstable approach" thus invites us to look more closely at "approach and landing," and to identify the variety of tasks and techniques that are encompassed. These five flight sub-phases will be shown to have value in flight analysis.

Severity-last event taxonomy

Conventional practice groups events first by the severity of the adverse outcome, and secondly by the kind of event. For example, "accidents" are the group of events most commonly analyzed for safety purposes, and after events are grouped into "accidents," they are then sub-divided into kinds of accidents, such as approach and landing. This research suggests that more meaningful analysis may be possible if events are first sorted by kind of event (e.g., touchdown, using the five flight sub-phases), and secondarily by severity of outcome (excellent, acceptable, unacceptable, incident, accident).

There are perhaps several reasons why this kind of taxonomy has not already been implemented. First, it requires that significant bodies of non-accident data be available, including LOSA, anecdotal reports, and possibly quantitative FOQA results. Because the value of non-accident data is only slowly being recognized, and because (at least in the United States) of the reactive nature of public policy, there is insufficient motivation for meaningful incident and anecdotal data collection. GAIN seems limited in its potential because data is pre-selected and pre-processed before being shared, as opposed to all of the raw data.

Secondly, there seems to be a common misperception that incidents are precursors to accidents in the sense that if only one more event were present in an error chain, there would have been an accident, and therefore incidents are of less analytical value than accidents. However, incidents frequently had all the ingredients to be accidents, but a "defense" (in the sense of Reason's model) mitigated the event. In the case of unstable approaches, it seems likely that the "pilot involvement factor" hypothesized above may be a common "defense" against adverse consequences of unstable approaches.

Guidance vs. Judgment

It is informative to look at what mechanized guidance (meaning both commands and raw data displayed in the cockpit) is available to the pilot during these five sub-phases.

Flight Sub-Phase	Guidance	Comments
Rollout and turnoff	Visual cues centerline and runway remaining, but no steering commands	Relies on pilot skill, judgment, and experience for steering and braking
Flare and touchdown	Visual cues only, neither position nor guidance data used during flare, except possibly radio altitude to start flare	Relies on pilot skill, judgment, and experience
Final visual alignment	Mostly visual cues, although flight instruments may be occasionally referenced or called out	Relies on pilot skill, judgment, and experience
Inside the FAF	Radio navigation technologies or radar vectors.	Full guidance available with flight director; autopilot available
Outside the FAF	Radio navigation technologies or radar vectors.	Full guidance available with flight director; autopilot available

This table point makes clear that full guidance is not always available to the flight crew, and that sometimes skill, judgment, and experience are required. Other situations that require such judgment include slam dunk approaches, circling approaches, managing descent on non-precision approaches, and visual approaches. Observe that these judgment situations are considered to be higher risk than guidance situations, such as ILS approaches.

(It is also worth noting that contemporary alerting systems, such as wind shear, TCAS, and complete uninhibited alerts [at least on Boeing aircraft] are less prevalent the closer you get to the runway.)

Just as "pilot error" was an invitation to seek greater understanding, the phrase "unstable approach" thus invites us to observe and study the "guidance / judgment" dichotomy in the five landing flight sub-phases.

New Outcome Taxonomy

A new taxonomy is proposed to replace "approach and landing" "accident" and "incident"

The proposed new taxonomy for landing outcomes is:

New concept	Includes
First ground contact off the runway, IMC	CFIT; "unstable approach"
First ground contact off the runway, VMC	Visual illusions; windshear; "unstable approach"
Damaged on touchdown	Prolonged flare; visual illusions
Off the end of the runway	Runway overrun; loss of traction
Off the side of the runway	Runway excursion; loss of traction or visual cues

Recall the proposal that the severity of the outcome be secondary to the kind of untoward landing event. This is particularly apt when the common severity of these untoward landing outcomes is considered:

New concept	Common severity
First ground contact off the runway, IMC	100% fatalities, hull loss
First ground contact off the runway, VMC	Few fatalities, hull loss
Damaged on touchdown	Rare fatalities, major damage possible
Off the end of the runway	Rare fatalities, major damage possible
Off the side of the runway	Rare fatalities, minor damage

It is also appropriate to look at whether guidance or judgment is employed during these events:

New concept	Pilot Flight Path Information Processing
First ground contact off the runway, IMC	Guidance
First ground contact off the runway, VMC	Judgment
Damaged on touchdown	Judgment
Off the end of the runway	Judgment
Off the side of the runway	Judgment

Detailed analysis of runway overrun occurrences was performed, including accidents, incidents, and events. Because this analysis included both accidents and non-accidents, it showed that the sole differentiator between an overrun event and an overrun accident was whether the airplane encountered an obstacle, such as an embankment, body of water, or obstruction. However, these obstacles, which are threats to operational safety, are typically not charted. The VP of one charting company told me that such data was not charted because overrun lengths could not be credited towards required landing distance.

His comment, in turn, brings up a second observation. Our profession commonly refers to “flight” safety, and to “flight” simulators, and to “flight” training. These linguistic idioms may reflect why ground operation safety, such as runway overrun obstructions, receives comparatively little safety and training emphasis.

“Unstable approach” thus invites us to look more closely runway overruns, and to make these observations for future study:

- Guidance vs. judgment in flight operations
- That study of non-accident events shows the necessary ingredient for runway overrun accidents
- That warning of such conditions is not necessarily available to flight crews
- That, indeed, the common language of aviators and safety analysts (“flight safety” vs “aircraft operational safety”) biases people to minimize consideration of surface hazards and threats.

Unstable approach as a symptom

Don Bateman’s excellent book, “Flight into Terrain,” July, 1997, documents 280 CFIT (controlled flight into terrain) and CFTT (controlled flight towards terrain) events during approach and landing. A manual tabulation of those events shows that for those flights where data was adequate to make a determination, the majority of those flights that crossed the final approach fix (FAF) failed to do so satisfactorily – they were too high or too low, for example.

This suggests at least these two points:

- What factor(s) were at work to cause the flight crews to inappropriately cross the FAF?
- For those flights in which the FAF was crossed inappropriately, labeling the rest of the approach as “unstable” contributes nothing to understanding what occurred. Worse, it diverts attention away from those unarticulated factors causing the failure to cross the FAF satisfactorily.

Conclusions

The term “unstable approach,” like its great-grandfather “pilot error,” is a term worthy of retirement from the safety analyst’s vocabulary. However, “unstable approach,” like “pilot error” before it, is an invitation to new ways of articulating and then addressing important safety issues. While the new concepts suggested in this paper may or may not survive critical analysis by the flight safety community, their value is not to be measured by their survival, but by whether or not the flight safety community accepts their challenge to rethink “unstable approach” in the same way that “pilot error” was completely rethought, and whether this rethink ultimately reduces accident and incident rates.

Some of these new ways of analyzing flights for safety may include:

- Five sub-phases to replace “approach and landing”
- Guidance vs. Judgment analysis
- Severity-first taxonomy to replace “accident” and “incident”
- Unstable approach as a symptom of other phenomena
- “Pilot involvement factor”

This paper also demonstrates the clear and obvious value of using data from all of flight operations to improve safety analysis and ultimately, the safety record of the industry. Failure to expand safety analysis techniques and data collection to new sources of data will result in failure to substantially improve flight safety. As the old adage states, “If you always do what you always did, you’ll always get what you always got.”

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