FLIGHT SAFETY FOUNDATION

Final Report to Flight Safety Foundation

Go-Around Decision-Making and Execution Project

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3 Executive Report

This executive report is intended for those who require an understanding of the problem, a brief overview of how the project research and analysis were conducted, and a listing of the significant findings and recommendations. Readers and front line managers who may need or want more details of the problem, research and analysis, and a complete listing of findings and recommendations can refer to the full report that follows.

3.1 The Go-Around Noncompliance Problem

Approach and landing is the most common phase of flight for aviation accidents, accounting annually for approximately 65 percent of all accidents. A Flight Safety Foundation study of 16 years of runway excursions determined that 83 percent could have been avoided with a decision to go around. In other words, 54 percent of *all* accidents could potentially be prevented by going around. It is generally felt that an unstable approach is the primary cause of landing excursions. However, within this 16-year period, just over half of the landing excursions followed a fully stable approach; in these instances, the flight became unstable only during landing. A critical industry policy designed to help prevent such accidents is the go-around policy. Interestingly, and sadly, the collective industry performance of complying with go-around policies is extremely poor — approximately 3 percent of unstable approaches result in go-around policy compliance. Why is a critical policy designed to prevent the most common type of accident ignored by flight crews, and why is that policy not being managed effectively by management? Improving the go-around compliance rate holds tremendous potential in reducing approach and landing accidents (ALAs). The go-around itself is not without risk. There is an increased risk in loss of control events during a go-around compared to exposure with all other phases of flight. It follows that we should only go around when the risk associated with an unstable approach is greater than the risk associated with a go-around. What is that balance, and how do we minimize go-around exposure to only those that are really necessary? The Flight Safety Foundation Go-Around Decision-Making and Execution Project was launched to research and answer the question "Why are we so poor at complying with established go-around policies?" It was also intended to improve our understanding of the risks associated with executing go-arounds and to make recommendations to improve compliance and mitigate risks associated with the go-around maneuver itself.

The full report includes complete research, analysis, findings, strategies and recommendations for industry corrective action, and future work required. As such, it is meant as a source for the development of easier-to-use operator reference products such as guidelines and checklists.

3.2 Research and Analysis

Many ALAs have been investigated thoroughly over time, and much is known about contributing factors. What is lacking, however, is an understanding of the psychology of noncompliance. Research and analysis of go-around decision making have been conducted primarily from the psychosocial science perspective to gain an understanding of the psychological drivers of noncompliance, and to identify corrective steps that can be taken, based on science. This is the first industry analysis of its type for this specific problem. The Presage Group conducted the research and analysis, based on its situational model of nine distinct constructs, or attributes, from two global studies via web-based surveys; one survey analyzed the psychology of noncompliance by flight crewmembers, and the other examined the psychology of management's actions in handling company go-around policies. Detailed analysis can be found in the full report.

For the go-around execution research, an accident and incident review was conducted that included a non-random selection of published accident and serious incident reports about go-around events involving transport category aircraft between 2000 and 2012. A total of 64 go-around events were included. In some, the safety of the go-around was central to the accident or incident investigation; in others, the aftermath of the go-around was the main purpose of the investigation. The events involved single-aisle jets (64 percent), twin turboprops (20 percent) and twin-aisle jets (16 percent).

The context, safety aspects and overall level of risk of each event were analyzed and characterized by a review team. Each event was assigned to one of three categories according to the degree of risk presented by the go-around: high risk (18 events), moderate risk (25 events) and non–risk-bearing (21 events).

In the two risk-bearing categories, six "headline" go-around safety issues (GASIs) were identified with respect to the initiation and conduct of each go-around. Most of the 43 risk-bearing events were associated with a single GASI, but five events were associated with two GASIs. Each risk-bearing event also was assigned one of three "outcome risks": loss of control–in flight, controlled flight into terrain or midair collision.

3.3 Significant Findings

An effective policy has three main attributes: It is well thought out and clearly written to balance the needs of safety and mission accomplishment; company management handles the policy consistently; and company front line employees' awareness is such that the policy is carried out reliably. Research revealed weaknesses in all three attributes at the industry, operator and employee levels.

High-level significant findings are:

1. The collective industry norm is to accept the noncompliance of go-around polices, despite empirical data that indicate this is the most common contributor to ALAs.
2. The industry predominantly turns to reducing unstable approaches as the sole means to reduce ALAs, even though empirical data show that unstable approaches affect less than half of runway excursions.
3. Pilots' overall awareness of ALA risks — and of the impact those risks have on approach and landing safety — is low.
4. Management is generally disengaged from go-around noncompliance and has low awareness of the impact it has on ALAs. Management's perception of risk is low.
5. Pilots do not see current go-around policy criteria as realistic for the operational environment.
6. Effective go-around decision making in flight deck communication is low.
7. Go-arounds, although considered a normal flight maneuver, are rare.
8. As reported by flight crews, one in 10 go-arounds has a potentially hazardous outcome, such as an aircraft performance exceedance.
9. There are variable go-around techniques and challenges, depending on the point during the approach when the go-around begins. Procedures and training do not adequately address many of these challenges.
10. Pilot experience in the aircraft type affects go-around proficiency.
11. Go-around complexity, including complex controller radio transmissions, can affect go-around proficiency.

3.4 Recommendations

It is evident that the state of noncompliance has been steady for many years and will remain steady unless changes are made. First and foremost, the industry must improve its awareness of the problem; a shift in focus and cultural norms is required. It is believed that significant improvement is attainable; however, the cultural shift will be easier if the industry shifts collectively, as opposed to individual companies attacking the issue on their own, as several are already doing.

As stated above, three key attributes of an effective policy are: The policy makes operational sense to both the employees who execute it and those who manage it; the policy is managed effectively to a level that satisfies company objectives; and the employees who should follow the policy are very aware of that policy and the environment in which it is applied. As such, the following recommendations touch upon these key attributes. More detailed recommendations can be found in the full report.

High-level strategic recommendations for go-around decision making include the following:

1. Ensure the policy makes sense operationally.
    a. Update the stable approach definition and stable approach height to maximize their relevance among flight crews, and their manageability among management.
    b. Separate the stable approach definition and criteria from decision-making criteria to improve awareness that these are two distinct aspects of go-around policies, and that decision making is viable beyond the defined approach phase. This separation does not imply that these two distinct areas cannot meet at points throughout the approach and landing; rather, it is intended for developers of standard operating procedures and communication procedures to break the psychological attachment of these two aspects.
3. Manage the policy effectively.
    a. Operators set specific compliance rate targets (key performance indicators), and establish initiatives to achieve them.
    b. Amend industry and regulatory audit programs to include standards and recommended practices that address go-around noncompliance (GANC).
3. Increase situational awareness.
    a. Increase awareness of GANC and risks associated with continuing to land when unstable, and the significant impact that noncompliance has on ALAs among:
        i. Operator management;
        ii. Flight crews;
        iii. Industry and pilot associations;
        iv. Regulators; and,
        v. Manufacturers.
    b. Enhance situational awareness (psychosocial awareness) to heighten flight crews' awareness throughout the approach and landing through:
        i. Policy and procedural enhancements;

ii. Communication improvements; and,

iii. Minimizing the subjectivity of go-around decision making for the decision maker (e.g., the pilot flying or captain) to mitigate those components of situational awareness that compromise the pilot's risk assessment and decision-making ability.

Each recommendation helps improve the psychological drivers that affect good decision making, and it is this objective that the recommendations were specifically designed to address. Although all strategic recommendations are important and should be implemented as part of a holistic approach, a few are worth highlighting. First, if an operator has the means to install automated stable approach and landing alerting systems, it should be a priority. These systems address many of the psychological issues associated with noncompliance and could be the single most effective way to improve go-around decisions. Second, management must be more involved in managing the policy/problem — an area where management has been very much absent. Key steps to be taken by management are to set go-around compliance rate targets consistent with safety management system principles, and to investigate and follow up (non-punitively) on each approach that continues to an unstable landing. Finally, flight crew situational awareness needs to be improved — primarily through better communication throughout the approach and landing, which can be achieved largely through active communication techniques as part of standard operating procedures.

High-level strategic go-around execution recommendations:

1. Ensure that go-around training and awareness appropriately reflect different go-around execution risk scenarios.

2. Review go-around policy, procedures and documentation to maximize their effectiveness, clarity and understanding.

3. Ensure that low relevant experience of one or both crew does not prejudice the effectiveness of monitoring during approach, landing and go-around.

As with any significant program change, desired, and undesired, effects should be closely monitored by appropriate audit programs such as flight data analysis (FDA), line operations safety audits (LOSA) or International Air Transport Association (IATA) Operational Safety Audits (IOSA).

3.5 Action Taken

In light of the findings and recommendations, it is apparent that revisions are required to Flight Safety Foundation's "Recommended Elements of a Stabilized Approach" and *Safe Landing Guidelines*. Analysis indicates there are facets of that guidance that are not optimal for effective decision making and that may encourage go-arounds for approaches that may be of very low risk. When this report was being published, the analysis for such revisions had already taken place, but the project review committee recommended an operational trial before changes in the Foundation's guidelines are formally adopted. (See Appendices 10.3 and 10.4 for Flight Safety Foundation's "New Stabilized Approach and Go-Around Guidelines, 2017 (proposed for industry validation)" and "Revised Safe Landing Guidelines, 2017 (proposed for industry validation).")

3.6 Project Conclusion (Executive Report)

The problem of go-around policy noncompliance is real and is arguably the greatest threat to flight safety today, and the potential impact of improvement in compliance is significant. No other single decision can have such an impact in the reduction of aviation accidents as the decision to go around.

The industry must improve its awareness of the problem; to accomplish that, a shift in focus and cultural norms is required. It is believed that significant improvement is attainable; however, the cultural shift will be much easier if the industry shifts collectively, as opposed to individual companies taking individual action. However, several companies already have chosen to go it alone on this issue.

The project accomplished the goals of the 2011 document that outlined the terms of Flight Safety Foundation's Go-Around Safety Initiative — "to understand the noncompliance by flight crewmembers, and noncompliance of quality control measures by flight managers," and to consider the safety risk associated with go-arounds and ensure that the transfer of risk is understood.

There are several useable guidelines in the appendix of the report. Not all envisioned products have been completed, however, and this is noted in the report as work yet to be done by Flight Safety Foundation.

4 Background

In 2008, Flight Safety Foundation's International Advisory Committee (IAC) was briefed[1] about concerns that go-arounds often were not being conducted when an unstable approach occurred below the stable approach height (SAH). The ensuing discussion concluded in agreement that the issue should be studied further. Interestingly, the Foundation's European Advisory Committee (EAC) began its own discussion related to go-arounds, the lack of unstable approach policy compliance, the risk of the go-around maneuver itself, and what effect air traffic services (ATS) providers could have on the issue. These discussions led the Foundation to look more deeply into the empirical data supporting such concerns.

Failure to conduct a go-around is the number one risk factor in approach and landing accidents (ALAs) and the number one cause of runway excursions (Burin, 2011: The Year in Review). Recent analyses of data from 1994 through 2010 indicate that 33 percent of all accidents are runway excursions, and that they are the most common type of accident (Burin, 2011: The Year in Review) (Tarrel). Unstable approaches occur on 3.5 to 4.0 percent of all approaches, and 95 to 97 percent of flight crews whose airplanes are in this state continue the approach to landing (Burin, 2011: The Year in Review) (Klinect) (Pursey, Evidence Based Training). In "Analysis of Approach and Landing Accidents and Serious Incidents" — one of several studies conducted by Flight Safety Foundation's Approach and Landing Accident Reduction (ALAR) Task Force and published by the Foundation in 1999 — the task force conducted an in-depth analysis of 76 accidents and incidents that occurred from 1984 through 1997. The task force found that a go-around was initiated in only 17 percent of the occurrences and said that "given the evidence … analysts expected the initiation of a higher number of go-arounds in practice" (Flight Safety Foundation ALAR Task Force).

Approximately 65 percent of all accidents are ALAs (W. F. Curtis) (IATA). One analysis concluded that more than 80 percent of ALAs would have been preventable — if the crew had decided to go around (Burin, 2011: The Year in Review). Simply calculated, potentially about half of *all* accidents could be prevented with a decision to go around. No other single decision can have such an impact on the overall aviation accident rate. Although all of these studies are somewhat subjective, the consistencies from study to study indicate the problem is real and is of the magnitude the studies indicate. Clearly, a go-around decision can yield great benefits, but what about the risks associated with the go-around maneuver itself?

There is no shortage of informative studies that have analyzed what occurred during ALAs and what factors contributed to the accidents. However, no known study has examined flight crew decision making from a psychological perspective to determine why some crews continued with an unstable approach, knowingly violating company policies, and why others elected to go around. What are the drivers of intentional noncompliance with a critical safety policy?

The ALAR Task Force's analysis of approach and landing accidents and serious incidents identified "poor professional judgment/airmanship" (i.e. decision making) as the most frequent casual factor, occurring in 74 percent of the 76 events. Another form of poor decision making — "press-on-itis," or continuing an approach when conditions suggest otherwise — accounted for 42 percent of all occurrences (Flight Safety Foundation ALAR Task Force).

More questions arise about the actions, or inactions, of company management in these events. If the data have been consistent for many years, why have managers not been able to correct the problem? With such a low industry compliance rate, some basic questions about management's role need to be answered: Are they aware of the noncompliance rates, and if so, then why have they been unable to mitigate or improve compliance with established go-around policies? If they are not concerned with the poor compliance rate, why not? Management issues were not cited in any of the 13 conclusions of the ALAR Task Force's final "Analysis of Fatal Approach and Landing Accidents." However, in the Task Force's conclusions of a related study — "Analysis of Approach and Landing Accidents and Serious Incidents" — "company management failure" was identified as a circumstantial factor in 46 percent of the occurrences (Flight Safety Foundation ALAR Task Force).

Based on these analyses, better awareness of the problem, and new questions, Flight Safety Foundation initiated the Go-Around Decision-Making and Execution Project (2011). It was designed as a joint EAC–IAC project, with each committee focusing on one specific aspect of the issue; the IAC focused on go-around decision making, and the EAC focused on the performance of the go-around.

1 Curtis, William. IAC meeting. Boeing, Seattle. 2008. presentation

5 Go-Around Decision Making

5.1 Flight Crew

5.1.1 Methodology and Information Collection

The Presage Group was commissioned by Flight Safety Foundation to conduct research and analysis on the psychology of factors contributing to intentional noncompliance. The basis for much of the following comes from two studies conducted by Presage — one that analyzed the psychology of flight crew decision making during unstable approaches, and another that analyzed the psychology of company management decision making pertaining to addressing noncompliance with company go-around safety policies (Smith, Jamieson and Curtis, Why Are Go-Around Policies Ineffective? The Psycology of Decision Making During Unstable Approaches) (Smith, Jamieson and Curtis, Why Are Go-Around Policies Ineffective? The View From the Airline Manager's Desk). Although the issue extends beyond unstable approaches, the studies were conducted on this phase of flight as data were readily attainable from flight crews.

A psychological survey was developed that used unique questioning and experimental methodologies to understand the causation of compliant versus noncompliant flight crew go-around decision making. These techniques included assessing pilots' experiences using a series of questions designed to explore the psychological precursors of risk assessment and decision making. A second survey was designed to assess the perceptions, beliefs and experiences of airline managers and safety and operational personnel regarding unstable approaches and how they are managed at their host companies. To fully understand the systemic roots and dynamics of noncompliance with unstable approach policies across the industry, the results of the managers study were compared with those of the parallel flight crew study.

5.1.2 Flight Crew Event Recall — Study Segmentation

In this segment of the study, we asked pilots to recall recent specific instances of unstable approaches, at or below SAH (i.e., we asked for the *last instance* they had experienced). This special "situated recall" task elicited detailed descriptions of their experiences during the minutes leading up to and including a decision on whether to call for a go-around. These experiences include subjective aspects (e.g., their situational and risk assessments, felt social pressures, fatigue, beliefs about their companies' go-around policies, etc.) as well as their psychological representations of the objective factors characterizing the aircraft and the environment during their approaches (e.g., flight instabilities, visual reference conditions, environmental and air traffic control [ATC] factors, etc.). These variables constitute a full and in-depth recounting of the objective factors and their resulting psychological states during the critical time interval leading up to the decisions — states that were hypothesized to be the highly important precursors of those decisions. In addition, to help refine the analysis, pilots also reported a variety of basic demographic information (e.g., rank, time on type, base of operations, etc.) and flight operational characteristics (long haul versus short haul operations, aircraft type, etc.). The content of the entire survey was thoroughly reviewed, commented upon and amended in accordance with the recommendations made by members of the IAC and EAC and other expert advisory team members.

The pilots were divided into groups:

- Those who only experienced continuing to land with an unstable approach (UA group);
- Those who only experienced a go-around (GA group); and,
- Those who had experienced both go-around and unstable approach events. Pilots in this group were randomly assigned to one of two groups — to recall a scenario in which they had flown an unstable approach but did not call for a go-around, or to recall a go-around event.

This random experimental assignment allowed us to confidently identify objective and psychological situational factors associated with noncompliance with go-around policies regarding go-around decision making. Pilots who reported they had only flown a go-around or an unstable approach recently (i.e., in the last five years) recalled their last event of those respective types.

The main set of psychological and psychosocial factors assessed was a differentiated set of nine facets of awareness that "unpack" the concept of situational awareness in a comprehensive and holistic way, giving a rich phenomenological account of unstable approach and landing conditions as they are lived, and providing useful and targeted guidance for mitigations. This set of psychosocial awareness constructs (Presage Group) includes the aspects detailed in Table 1 (p. 8), which comprise an inter-related system of mutual causation. It was hypothesized that greater awareness on each of the nine awareness dimensions would be associated with making better assessments of risk and decisions to go around; in general, greater situational awareness competencies

Table 1

Glossary of Presage Situational Awareness Constructs (Pilots)

Construct Name	Description
Affective awareness (C1) "Gut feeling for threats"	Pilot's gut feeling for threats; seat of the pants experience, which is characterized by an emotional, sensory experience that triggers further cognitive analysis
Anticipatory awareness (C2) "Seeing the threats"	Pilot's ability to see and/or monitor real and potential threats as they move and change over time and space
Critical awareness (C3) "Relying on experience"	Pilot's ability to draw from his or her personal and professional experience bank to assess here-and-now events as "normal"
Task-empirical awareness (C4) "Knowing the limits"	Pilot's expert knowledge of the operational envelope of his or her equipment
Functional awareness (C5) "Knowing the instruments and equipment"	Pilot's expert knowledge of how to read and translate what his or her instruments say
Compensatory awareness (C6) "Adjusting to threats"	Pilot's ability to know how and when to compensate or adjust correctly for present and anticipated future operational conditions in order to ensure safe and compliant operations
Hierarchical awareness (C7) "Knowing the procedures"	Pilot's expert knowledge of operational procedures, their order and correct sequencing
Relational awareness (C8) "Keeping each other safe"	Pilot's ability to accurately assess and engage crewmember relationships in a manner that protects safety and compliance
Environmental awareness (C9) "Company support for safety"	Pilot's experience of how the company supports and encourages safety and how this in turn shapes his or her commitment to safe and compliant behavior

Source: The Presage Group for Flight Safety Foundation

are associated with more operationally compliant decision making.

5.1.3 Pilot Go-Around Thresholds — Study Segmentation

A second experiment was included in this survey, and we report some findings below, but the details are too numerous to fully describe here. This experiment was designed to uncover the environmental and physical instability parameters that influence pilots' perceptions of the risks inherent in flying unstable approaches, and to examine when their attention to these parameters affects their judgments about when to call for go-arounds. In this study, pilots were presented with a hypothetical flight scenario in which they were randomly assigned to receive variations in the severity of the risk associated with wind conditions, runway conditions/braking action and runway length. They were then asked at what degree of deviation, on five different flight parameters, those variations would cause them to call for a go-around. Pilots were instructed to report on their likelihood of calling for a go-around, based on their own *personal* risk criteria, not those of their companies or of the industry, on this set of five flight parameters, and to do so at different altitudes. This allowed us to infer where on the flight path different risk factors become personally salient and important as drivers of pilots' judgments to go around, and how these factors might interact. The objective was to determine whether there was basic alignment between pilots' perceptions about when there is a need to call for a go-around and general company/industry policies about when these instabilities necessitate such a decision. In case of evidence of any gaps between these two, our goal was to use these data to guide realistic recommendations about changes in policy that might bring them into alignment while ensuring that safety would not be compromised. To the extent that pilots do not see current policies as constituting a set of legitimately unsafe conditions, they are likely to ignore such standard operating procedures (SOPs) and engage in potentially riskier, noncompliant flight behaviors. This was an experimentally based attempt to explore pilot perceptions of what *should* constitute the conditions to go around, in *their* experienced judgment, and to begin to develop a view about whether such beliefs could be or should be incorporated into policy guidance and SOPs in a way that would help ensure compliant, safe behavior.

5.1.4 Pilot Respondent Sampling

Respondents to this survey were solicited through direct communication with safety personnel at various pilot associations and FSF-member and non-member airlines globally, as well as through various social media forums. The goal was to invite and administer the online survey to as many pilots as possible from around the world, representing a variety of fleets, aircraft, flight operations, respondent experience levels, cultures, physical geographies, and so on. Anonymity was assured to inspire honest and complete self-reports of pilots' experiences, as well as to stimulate participation. The 2,340 pilots who completed the survey included those with a good range of pilot experience on a variety of operational types, as well as wide geographical representation,

Table 2

Sample Characteristics *(n=2,340)*

Variable	Category	Percent of sample
Gender	Male	97
	Female	3
Continent of operations	Africa	1
	Asia	25
	Europe	28
	North America	34
	Oceania	0
	South America	12
First language	Non-English	56
	English	44
Initial training	Non-military	74
	Military	26
Current position	Captain	66
	First officer	33
	Relief pilot	1
Flight hours (career)	Median	10,000
	Range	200 – 31,000
Aircraft operation	Passenger	88
	Charter	4
	All cargo	7
	Corporate	<1
	Inactive	<1
Type of operation	Short-haul	62
	Long-haul	38

Note: Percentages for some variables do not total 100 because of rounding.

Source: The Presage Group for Flight Safety Foundation

suggesting our results can be generalized to pilots worldwide (Table 2).

5.2 Management Study

In this study, we asked safety managers at major airlines — those with the authority to recommend or enact changes in unstable approach criteria and policy/procedures, as well as those responsible for day-to-day quality control of flight operations — a series of questions regarding their views of the safety practices, procedures and organizational cultures within which unstable approaches and go-arounds occur in their own airline operations. Specifically, we asked such managers about the rates of compliance with unstable approach policies that they believed their airlines experienced, as well as the compliance rates experienced by the commercial industry as a whole. Beyond this basic knowledge, we asked whether they were satisfied with their airline's performance on compliance with their unstable approach–go-around policies and procedures, and whether they thought them effective, about their perceptions of the clarity and appropriateness of these policies and procedures, about their beliefs that they had the support (informational support and organizational approval) to manage their company's go-around rates, and about their overall assessment of how urgently they believed that the risks (if any) perceived in their go-around rates needed to be addressed (if at all). The content of the entire survey was thoroughly reviewed, commented upon and amended in accordance with the recommendations made by members of the IAC, the EAC and other expert advisory team members.

As in the pilot study, the main set of psychological and psychosocial factors assessed were included in a differentiated set of nine facets of awareness, "unpacking" *situational awareness* in a comprehensive way, giving a phenomenological account of how effectively, from a manager's experience, they are managing pilot compliance with the unstable approach–go-around policies. This set of psychosocial awareness constructs (The Presage Group) includes the aspects detailed in Table 3 (p. 10), which comprise an inter-related system of mutual causation. Table 3 describes the nine facets in a context associated with a managerial role.

5.2.1 Management Respondent Sampling

The managerial respondents whose participation was solicited for this Flight Safety Foundation–sponsored survey were contacted via email communication/invitations from the Foundation, International Air Transport Association (IATA) and Airlines for America (A4A), as well as by several airlines. Anonymity was assured to inspire honest and complete self-reports of managers' beliefs and opinions.

As was true of the pilot sample, with the managers who completed the survey, we achieved wide geographical representation, suggesting that our results can perhaps be generalized to management personnel worldwide (Table 4, p. 11); however, several caveats are explained below. In fact, the distributions — by gender, continent and language — in the managers' sample were nearly identical to those in the pilots' sample. While few directors completed the survey, there were a sizeable number of mid- and senior-level managers in the sample. However, a subsequent question about respondents' roles and responsibilities within their airlines for recommending and leading change in unstable approach–go-around policies and procedures revealed that only 63 percent of those in the sample had such authority. Also included were respondents who were responsible for quality control of day-to-day

Table 3

Glossary of Presage Situational Awareness Constructs (Management)

Construct Name	Description
Affective awareness (C1) "Gut feeling for threats"	Manager's gut feeling for threats; seat of the pants experience or "spider sense," which is characterized by an emotional, sensory experience that triggers further cognitive analysis
Anticipatory awareness (C2) "Seeing the threats"	Manager's ability to see and/or monitor real and potential threats as they move and change over time
Critical awareness (C3) "Relying on experience"	Manager's ability to draw from personal and professional experience to assess here-and-now events as "normal"
Task-empirical awareness (C4) "Knowing the limits"	Manager's expert knowledge of the operational envelope of his or her policies and procedures; in other words, knowing the boundaries
Functional awareness (C5) "Knowing the performance metrics"	Manager's expert knowledge of how to read and translate what data about his or her policies and procedures mean
Compensatory awareness (C6) "Adjusting to threats"	Manager's ability to know how and when to compensate or adjust correctly for present and anticipated future operational conditions to ensure safe, compliant operations
Hierarchical awareness (C7) "Knowing the procedures"	Manager's expert knowledge of operational policies, procedures, their order and correct sequencing
Relational awareness (C8) "Keeping each other safe"	Manager's ability to accurately assess how his or her actions in managing the internal policies and procedures either facilitate and protect safety and compliance or compromise them
Environmental awareness (C9) "Company support for safety"	Manager's experience of how the company supports and encourages safety compliance and how this in turn shapes his or her commitment to safe and compliant behavior or adherence to the operational policies and practices

Source: The Presage Group for Flight Safety Foundation

flight operations, irrespective of whether their role included policy development or implementation.

The considerable efforts that we made in our outreach and engagement strategy for the survey garnered 880 unique visits to the survey portal. We consider this number of hits to be very good, indicating that the engagement strategy drove a meaningful number of airline managers to the site. However, of those visiting, only 164 (18.6 percent) completed the survey, a response rate low in both absolute terms, and relative to the rate of participation among pilots (34 percent), who were asked to complete a much longer and more demanding survey. This low response rate constitutes, we believe, the first evidence pointing toward disengagement with the topic of unstable approach–go-around policy and procedures among airline flight operations personnel at the managerial level. This is especially true when we consider that the original criterion for inclusion in our final analysis stipulated that respondents must be in a position to develop and influence unstable approach–go-around policies and procedures at their airlines by virtue of their authority to recommend or make changes. Based on this inclusion criterion and an analysis of respondents' self-reported roles and responsibilities, we achieved a sample of only 103 qualified respondents. To increase the sample size for analysis, we widened the sample frame to include those respondents responsible for quality control of day-to-day flight operations at their airlines, even if they did not have policy development responsibilities. (Note: A thorough comparison of the latter group with the original target revealed no systematic differences in their survey responses, justifying their inclusion in the final sample.) The study, therefore, reports the results from 128 managers (78 percent of all survey respondents and 15 percent of survey site visitors).

This low response rate essentially disallowed us from analyzing data for a second, experimental task of determining personal go-around thresholds for unstable approach risk among managers, similar to the pilots' go-around threshold experiment. Meanwhile, in light of the low response rate, a caveat must be issued for all other results that we report below. That is because the normative response to the survey invitation among managers worldwide was to choose *not* to participate; therefore, we must question whether this was a valid and reliable sample of managers. That said, the results, although based on this small sample, are highly suggestive of trends in managers' perspectives on unstable approach–go-around policies and procedures. While we are unsure if the sample is, in fact, biased, our intuition tells us that any sample bias, if present, would tend toward having surveyed managers who are more engaged, aware and concerned about the issue than those who are less so. If this is true, these results may more likely over-represent the degree of awareness and concern about unstable approach–go-around noncompliance that exists in the industry.

5.3 Industry Sensing

Throughout the project, there have been numerous discussions with operators, regulators, manufacturers and

Table 4
Sample Characteristics

Variable	Category	Percent of sample
Gender	Male	100
	Female	0
Continent of operations	Africa	2
	Asia	23
	Europe	24
	North America	34
	Oceania	4
	South America	13
First language	Non-English	53
	English	47
Current position	Manager	32
	Senior manager	23
	Check airman	13
	Captain/pilot	10
	Instructor	8
	Supervisor	5
	Director (or above)	2
	Other/not reported	7
Roles/responsibilities for developing policies and procedures for UAs and GAs	Make recommendations only	36
	Make recommendations and changes	44
	QA, but not policy development	20

GA = go-around; QA = quality assurance; UA = unstable approach;

Source: The Presage Group for Flight Safety Foundation

investigative bodies, and conference and meeting presentations with follow-on conversations. Off-the-record accounts from agencies not wishing to be identified indicate that, of those that have tracked go-around compliance, rates are in the range of those discussed above (3 to 5 percent), and that they have been in that range for a protracted period of time. The exceptions are a couple of airlines that indicated their go-around compliance rates approach 100 percent.

Additionally, they say that their flight data acquisition programs are set to report out when the number of stable approach parameter exceedances is greater than one. The U.S. Federal Aviation Administration's (FAA's) Aviation Safety Information Analysis and Sharing (ASIAS)/flight operational quality assurance (FOQA) definition says an unstable approach occurs when more than two parameters are exceeded between 1,000 ft above ground level (AGL) and 500 ft AGL, or below 500 ft (The Mitre Corporation). Most unstable approach–go-around policies require a go-around when one or more parameters are exceeded.

Often, the conversation begins with go-around policy noncompliance and expands to include discussions of unstable approaches and how they can be prevented in order to mitigate runway excursion ALAs.

5.4 Analysis: Pilot Decision Making

5.4.1 Overview of Results

The design of this study enabled us to look at the differences between those pilots who were compliant with their companies' policies and those who were not, according to objective and subjective measures. Table 5 (p. 12) presents data for the demographic, flight operational and objective factors present in the unstable approach events reported by pilots. Table 6 (p. 13) shows results for the psychological measures taken, that is, the Presage situational awareness variables, psychosocial factors (fatigue, risk assessment, etc.) and crew interactions. Table 7 (p. 14) illustrates findings for the measures of how pilots, in hindsight, evaluated the outcomes of their decisions and what they perceived as the main influences on their choices (i.e., personal, interpersonal, operational and organizational).

In these three tables, pilots are divided into four different groups for comparison:

1. Go-around–only history/GA group (27 percent of sample): pilots who reported they had only flown one or more go-arounds in the last five years but no unstable approaches;
2. Mixed history/GA group (16 percent): pilots who had flown one or more go-arounds and one or more unstable approaches in the last five years and who were randomly assigned to recall their last go-around event;
3. Mixed history/UA group (36 percent): pilots who had flown one or more go-arounds and one or more unstable approaches in the last five years and who were randomly assigned to recall their last unstable approach event; and
4. Unstable approach–only history/UA group (21 percent): pilots who reported they had only flown one or more unstable approaches in the last five years but no go-arounds.

A comparison of groups 2 and 3 (a combined 52 percent of the total sample) within each table represents one focus of the analysis, as these pilots were the only ones randomly assigned to groups. This random assignment controls for

Table 5

Results for Pilot and Flight Scenario Characteristics

	Pilot Types/Recall Conditions				p < 0.05	
	(1) GA-Only History/ GA Group	(2) Mixed History/ GA Group	(3) Mixed History/ UA Group	(4) UA-Only History/ UA Group	(1) and (2) vs. (3) and (4)	(2) vs. (3)
Pilot demographics						
% Male pilots	97	95	96	96	ns	ns
% Captains	64	64	58	46	Y	ns
% First officers	34	35	39	52	Y	ns
Average total flight hours at time of event	9,005	10,077	9,495	8,557	ns	ns
Average total flight hours on type at time of event	3,163	2,757	3,099	2,830	ns	ns
% Respondents whose first language was same as crew	82	78	85	86	Y	Y
% Base of operations: Asia	24	27	14	20	Y	Y
% Base of operations: Europe	20	20	26	33	Y	ns
% Base of operations: North America	17	43	42	42	Y	ns
% Base of operations: South America	35	2	11	2	Y	Y
Flight Characteristics						
Recency of Event (Mean months in past)	26	38	37	32	ns	ns
% Short haul	76	82	78	76	ns	ns
% Long haul	24	18	22	24	ns	ns
% VMC approaches	68	73	85	86	Y	Y
% IMC approaches	17	17	8	7	Y	Y
% Precision approaches	48	36	38	39	ns	ns
% Nonprecision approaches	20	16	12	11	Y	ns
% Approaches with active instrument reference	33	32	35	33	ns	ns
% Approach without active instrument reference	7	12	6	12	ns	Y
% Manual approach to recognition of instability	37	49	44	42	ns	ns
% Automated approach to recognition of instability	39	22	29	25	ns	ns
% Combined manual and automated approach	24	29	26	32	ns	ns
% Unstable at stable approach height	68	77	85	88	Y	Y
% Unstable after stable approach height	32	23	15	12	Y	Y
% Respondents who were flying	54	56	53	52	ns	ns
% Respondents who personally made the decision to go around	84	73	NA	NA	NA	NA
% Respondents who made the decision to continue unstable	NA	NA	59	50	NA	NA
% Respondents who discussed a go-around	NA	NA	46	41	NA	NA
Mean altitude at which decision was made (ft)	772	713	843	763	ns	ns
Incidence of instability factors (%):						
Flight path deviation	64	70	49	55	Y	Y
Aircraft speed exceeded V_{REF} +20 kt	50	58	63	64	Y	ns
Aircraft speed was less than V_{REF}	9	9	4	5	Y	Y
Sink rate exceeded 1,000 fpm	48	47	47	53	ns	ns
Power setting was not appropriate for the aircraft	42	47	51	57	Y	ns
Aircraft was not in the correct landing configuration	30	24	29	24	ns	ns
Briefings and checklists were not complete	16	13	14	16	ns	ns
Incidence of environmental factors (%):						
Tail wind	39	33	32	25	Y	ns
Wind shear	25	20	13	8	Y	Y
Turbulence	34	23	20	16	Y	ns
Insufficient visual reference	21	19	10	8	Y	Y
Contaminated runway	14	12	6	3	Y	Y
Incidence of ATC factors (%):						
Occupied runway	8	4	5	5	ns	ns
Inadequate separation on approach	12	10	11	13	ns	ns
Wake turbulence	9	2	3	3	Y	ns
Late clearance or poor approach vectoring	35	43	35	44	ns	ns

ATC = air traffic control; GA = Go-around; IMC = instrument meteorological conditions; NA = not available for comparison; ns = not significant; p = probability; UA = unstable approach; VMC = visual meteorological conditions; V_{REF} = reference landing speed; Y = statistically relevant

Note: Numbers in red for the two mixed groups represent statistically reliable effects.

Source: The Presage Group for Flight Safety Foundation

Table 6

Results for Psychosocial Factors

	Pilot Types/Recall Conditions				$p < 0.05$	
	(1) GA-Only History/ GA Group	(2) Mixed History/ GA Group	(3) Mixed History/ UA Group	(4) UA-Only History/ UA Group	(1) and (2) vs. (3) and (4)	(2) vs. (3)
Mean scores on Presage situational awareness constructs (6-pt; high=higher awareness):						
Affective awareness (gut feel for threats)	4.39	4.30	3.29	3.36	Y	Y
Functional awareness (knowing the instruments and equipment)	4.83	4.36	3.28	3.41	Y	Y
Critical awareness (relying on experience)	4.22	4.28	3.90	3.68	Y	Y
Anticipatory awareness (seeing the threats)	4.13	3.74	3.37	3.25	Y	Y
Task-empirical awareness (knowing the limits)	5.04	4.72	4.77	4.78	Y	ns
Compensatory awareness (adjusting to threats)	3.69	3.28	2.43	2.50	Y	Y
Relational awareness (keeping each other safe)	4.57	4.49	4.24	4.10	Y	Y
Hierarchical awareness (knowing the procedures)	4.73	4.42	4.19	4.22	Y	Y
Environmental awareness (company support for safety)	5.28	5.08	5.05	5.08	Y	ns
Mean scores on key psychosocial factors (6-pt; high=higher score on dimension):						
Presence of fatigue	2.85	2.75	2.92	2.74	ns	ns
Proper fatigue management	4.14	4.08	3.75	3.61	Y	Y
Ability to listen to/understand gut feeling warnings about risk	4.86	4.50	4.17	4.19	Y	Y
Ability to anticipate a GA	4.22	4.11	3.29	3.03	Y	Y
Confidence in GA performance abilities	5.36	5.29	5.34	5.28	ns	ns
General willingness to challenge crew	5.04	4.92	4.96	4.85	ns	ns
Event challenges to authority	3.02	2.83	2.93	2.92	ns	ns
Appropriate crew influence on GA decision making	4.98	4.95	4.79	4.56	Y	Y
Passenger pressure to land	4.26	3.61	3.80	3.78	ns	ns
Agreement with company UA/GA policies and procedures	4.78	4.29	4.24	4.37	Y	ns
Intolerance for deviance from GA policy and procedures	5.11	4.59	4.32	4.28	Y	Y
Anticipated company support for a GA decision	5.25	5.06	4.95	5.03	Y	ns
Assessment of the instability as risky/unmanageable	4.53	4.20	2.36	2.39	Y	Y
Company incentivization:						
% Who say their company reprimands pilots for performing UAs	46	50	45	43	ns	ns
% Who say their company reprimands pilots for performing GAs	3	7	4	4	ns	ns
Incidence of active consideration/discussion of instability factors (%)						
Flight path deviation	77	81	69	69	Y	Y
Aircraft speed exceeded V_{REF} +20 kt	86	83	71	66	Y	Y
Aircraft speed was less than V_{REF}	65	69	73	73	ns	ns
Sink rate exceeded 1,000 fpm	77	73	62	66	Y	Y
Power setting was not appropriate for the aircraft	73	61	59	58	Y	ns
Aircraft was not in the correct landing configuration	82	81	64	64	Y	Y
Briefings and checklists were not complete	71	44	57	54	ns	ns
Incidence of active consideration/discussion of environmental factors (%)						
Tail wind	66	65	71	68	ns	ns
Wind shear	73	73	80	88	ns	ns
Turbulence	55	75	49	58	ns	Y
Insufficient visual reference	59	69	71	59	ns	ns
Contaminated runway	64	88	60	43	ns	Y
Incidence of active consideration/discussion of ATC factors (%)						
Occupied runway	65	100	50	91	ns	Y
Inadequate separation on approach	62	67	62	80	ns	ns
Wake turbulence	42	100	60	83	ns	ns
Late clearance or poor approach vectoring	70	70	71	64	ns	ns

ATC = air traffic control; GA = go-around; ns = not significant; p = probability; UA = unstable approach; V_{REF} = reference landing speed; Y = statistically relevant

Note: Numbers in red for the two mixed groups represent statistically reliable effects.

Source: The Presage Group for Flight Safety Foundation

Table 7

Results for Hindsight Judgments

	Pilot Types/Recall Conditions				p < 0.05	
	(1) GA-Only History/ GA Group	(2) Mixed History/ GA Group	(3) Mixed History/ UA Group	(4) UA-Only History/ UA Group	(1) and (2) vs. (3) and (4)	(2) vs. (3)
GA-UA outcomes (6-pt; high=agree):						
Our GA was well executed	5.45	5.25	NA	NA	NA	NA
Our GA was well coordinated among the crew	5.41	5.26	NA	NA	NA	NA
Our GA was well coordinated with ATC	5.21	5.21	NA	NA	NA	NA
Our GA was flown as expected	5.43	5.18	NA	NA	NA	NA
Our landing was normal	NA	NA	4.74	4.76	NA	NA
Our landing was long	NA	NA	2.42	2.67	NA	NA
We experienced reduced control on the runway	NA	NA	1.45	1.39	NA	NA
We were off the centerline on touchdown	NA	NA	1.43	1.46	NA	NA
We had a hard/rough landing	NA	NA	1.55	1.49	NA	NA
We had negative passenger reactions	NA	NA	1.34	1.36	NA	NA
Post-flight evaluations of the decision and its outcomes (6-pt; high=agree)						
I felt we made the right decision to GA/continue the landing while unstable	5.77	5.74	3.51	3.50	Y	Y
If we had made opposite decision, it would not have altered the risk	2.89	3.03	3.41	3.18	Y	Y
Should not have made the decision we did	1.40	1.43	4.15	4.08	Y	Y
Called GA/engaged in risk (UA) needlessly	1.99	1.84	3.26	3.42	Y	Y
We got support from our company for the decision to GA/land in a UA	5.47	5.17	2.18	2.25	Y	Y
We got criticism from our company for the decision to GA/land in a UA	1.40	1.48	2.22	2.02	Y	Y
Company's SOPs for initiating go-arounds served us well (GA)/poorly (UA) that day	5.26	4.77	2.91	3.07	Y	Y
Changing views of GAs and UAs (%)						
% My views on calling GAs changed after experiencing this event	14	21	43	45	Y	Y
% My views on flying UAs changed after experiencing this event	17	21	43	45	Y	Y
Beliefs about degrees of influence on decision for (4-pt; high=strong influence):						
Aircraft instabilities	2.88	2.98	1.57	1.52	Y	Y
Weather	2.36	2.15	1.95	1.77	Y	ns
Fatigue	1.77	1.64	1.77	1.67	ns	ns
Crew coordination	1.82	1.87	2.10	2.12	Y	Y
Crew communication	1.74	1.88	1.96	2.09	Y	ns
Experience	2.44	2.61	2.68	2.85	Y	ns
Crew competency	1.88	2.09	2.18	2.35	Y	ns
Aircraft configuration	2.04	1.96	1.74	1.72	Y	Y
Company pressure to land	1.15	1.27	1.25	1.23	ns	ns
Commercial pressure to land (passenger connections, scheduling, etc.)	1.30	1.43	1.60	1.48	Y	Y
Peer/professional pressures to land	1.29	1.55	1.81	1.96	Y	Y
ATC pressure to land	1.29	1.36	1.37	1.30	ns	ns
Critical aircraft system(s)	1.25	1.27	1.10	1.06	Y	Y
Communication with ATC	1.57	1.54	1.52	1.55	ns	ns
Fuel levels	1.29	1.25	1.38	1.33	ns	ns
Personal resistance to managing the demands associated with a GA	1.29	1.44	1.63	1.61	Y	Y

ATC = air traffic control; GA = go-around; NA = not available for comparison; ns = not significant; p = probability; SOP = standard operating procedure; UA = unstable approach; Y = statistically relevant

Note: Numbers in red for the two mixed groups represent statistically reliable effects.

Source: The Presage Group for Flight Safety Foundation

chronic factors that would otherwise be “experimentally confounded” with their self-selection into a recall event condition (go-around or unstable approach) because they had recently experienced only that one type of event. Findings from a comparison of these groups are conservative, and represent situationally important factors associated with go-around decision making, not pilot dispositional factors. However, pilot tendencies and preferences associated with flying unstable approaches are, of course, present in the aviation community, and we will also point out in the data how such pilot dispositional factors may additionally contribute to noncompliance with go-around SOPs.

It is our belief that the best way to present the findings is to describe how pilots’ noncompliant behavior is a function of a decision-making process influenced by the in-flight aircraft and environmental factors that shape pilots’ decisions, their situational awareness competencies in encoding and interpreting the cues they receive about these aircraft and environmental factors, their personal perceptions of risk and risk tolerance that result, and their appetite for appropriate collaborative conversation about risk during the approach as an input to decision making. It is from both the pilots’ responses within each of these four classes of variables, as well as the interactions between the two pilots, that a complete descriptive, psychological profile for noncompliance emerges.

5.4.2 Pilot Situational Awareness Profile

Situational awareness of his or her environment, in all its facets, is the psychological prerequisite for a pilot to judge risk and then to make a decision to maintain compliance and safety in light of that judgment. This study used The Presage Group’s Situational Awareness Model for measuring and interpreting the psychological and social factors that collectively make up situational awareness. Recall that within this model, situational awareness comprises nine distinct but interconnected and seamless aspects of awareness. Much of our discussion will be framed around how each of these aspects influences a pilot’s decision-making processes, singly and in concert with one another, to remain compliant rather than noncompliant. (We note in passing that the Presage model classifies with an average 85 percent accuracy whether pilots are describing an unstable approach and landing or a go-around — 88 percent for unstable approaches and 82 percent for go-arounds — based only on its psychosocial measurements and excluding any knowledge of the objective factors present in the unstable approach scenarios reported. This means that our assessment of the experience of awareness, as we have measured it, does a good job of predicting pilots’ decision-making behavior — far beyond a 50 percent chance level of prediction).

The results of this study revealed, as hypothesized, that on all nine inter-related situational awareness factors, unstable approach pilots were significantly less aware than go-around pilots in the moments leading up to and including their go-around decision making — that is, they were less aware of their emotional responses to threat, less able to anticipate risk, more overconfident in their ability to compensate for the instability, and in less agreement with company SOPs, etc. In other words, the unstable approach–recall pilots scored much lower than did the go-around–recall pilots on every facet of situational awareness assessed. Seven of these nine differences held up statistically to the more rigorous analysis that compared just the experimentally assigned go-around and unstable approach pilots with one another. And eight of the nine differences between the experimentally assigned go-around and unstable approach pilots were even more pronounced when comparing the GA-only and UA-only groups.

It is meaningful to ask, “How does this awareness shape a pilot’s perception of risk?” Put simply, a pilot’s situational awareness competencies directly affect his or her perceptions and assessment of risk. The lower the degree of threat that pilots associate with instability and environmental factors — the perception of which is directly informed by their situational awareness — the lower the significance that pilots will place on the contributing factors and the less risky they will perceive the situation to be. Table 6 shows this result, with unstable approach–recall pilots reporting much lower assessments of the riskiness and unmanageability of their instabilities than go-around–recall pilots.

5.4.2.1 The Spreading Activation Effect of Situational Awareness Competencies

We have asserted that the inter-dependent nature of the facets of situational awareness means that a decline in one facet will produce a rapid deleterious effect on the others. This becomes clear when we consider the data relevant to this “spreading activation effect” of situational awareness facets. For example, this cross-contamination effect is evident among the unstable approach pilot groups, whose lower scores on their gut feel for threats (Table 6), as well as on actually seeing the threats, leave them vulnerable to minimizing both their assessment of the potential threat of aircraft instability and their ability to see the threat of instability as a risk to be managed correctly. The natural outcome is that more unstable approach pilots are unstable at SAH (Table 5). A corollary of these lower awareness scores is that unstable approach pilots also score lower in their ability to leverage crew relationships to maximize compliance and safety; Table 6 shows that unstable approach pilots are more likely to minimize efforts to consider and/or discuss with their crewmembers both instability factors (i.e., flight path deviation, aircraft V_{REF}+ 20 kt,[2] sink rate and landing configuration) and environmental factors (i.e., turbulence, contaminated runway and occupied runway).

It is the culminating effect of the aforementioned reduced awareness competencies that leaves the unstable approach pilots vulnerable to adopting a mental model that minimizes the risk of instability and reduces their attention to details. As the results for "knowing the instruments and equipment" and "knowing the procedures" indicate (i.e., functional and hierarchical awareness, in Table 6), unstable approach pilots are more tolerant of deviations from operational limits and procedures and less compliant with requirements that they perform all checklists and standard calls. Moreover, as these pilots commit to continuing with an unstable approach, they minimize what their professional experience could offer in executing what the SOP states (in Table 6, note "relying on experience" or critical awareness). In other words, when an unstable approach pilot is not tuned into salient information from his or her experience bank, he increases the risk profile of the operation and denies himself the opportunity to correctly adjust or compensate for the operational threat (in Table 6, "adjusting to threats" or compensatory awareness). The finding that unstable approach pilots more often than go-around pilots report being unstable at SAH confirms this missed opportunity to remain compliant (Table 5).

In concert with the former pattern is the finding that unstable approach pilots were more comfortable operating on the margins of the safety envelope (for example, in Table 6, note the lower scores on "knowing the limits" or task-empirical awareness), which translates to a greater tolerance for risk that is seen to be manageable. (Also in Table 6, note the assessment of the instability as risky/unmanageable.) If a pilot is paying less attention to his situational awareness competencies, he would likely also shut himself off from available resources, such as by using interpersonal relationships to protect operational safety and remain compliant (in Table 6, note "keeping each other safe" or relational awareness).

There are a number of significant findings at the granular level of this construct that tell a meaningful story. Most notable among these is that unstable approach pilots are relatively more likely than go-around pilots to feel crew pressure to land, to perceive a lack of crew support for a possible go-around decision, to feel discomfort in being challenged and in challenging others, and to feel inhibited about calling for a go-around because of the authority structure in the cockpit.

Also, go-around pilots are about four times more likely than unstable approach pilots (56 percent vs. 13 percent) to report recalling that an individual was prompting the crew to initiate a go-around. The evidence is clear that rather than leveraging the crew relationships as a tool for safe decision making, crew roles, expectations and communication had a suboptimal, even deleterious, effect. Finally, compounding this risk profile are the findings that unstable approach pilots score lower on "company support for safety" and that fewer than 50 percent of unstable approach–recall pilots believed they would be reprimanded for continuing an unstable approach to landing while, at the same time, maintaining that their company's criteria for when to execute a go-around are not realistic (Table 6). In the end, for the unstable approach pilots, there is less buy-in to company SOPs, and an incentive structure that "encourages," or is at least not seen to discourage, unstable approaches that are continued to a landing.

These results describe a situation that creates internal conflict for the unstable approach pilots, at least in hindsight, when they express regret for their decision to continue an unstable approach to landing (Table 7). Specifically, compared with go-around pilots, unstable approach pilots rated their flight outcomes less positively, believed less often that they had made the right decision, believed much more strongly than go-around pilots that they should not have made the decisions they did and, finally, agreed more strongly that they had engaged in needless risk.

5.4.2.2 Interpretation of 'Conflicting' Results

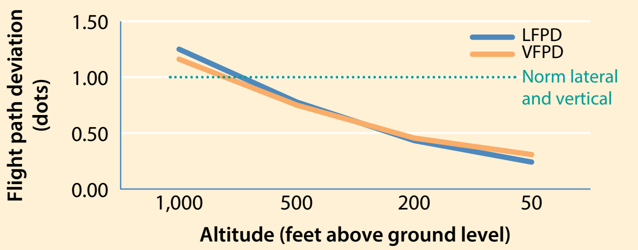
The results appear to imply a conflicting message from the unstable approach pilot group. On one hand, unstable approach pilots regret their decisions to continue an unstable approach and land, knowing that they have taken a risk, and yet, at the same time, they don't believe that the company's criteria for a go-around are realistic (Table 6). The latter may be, in part, a rationalization of their noncompliant decision, and one that they carry forward into the next such unstable approach situation. At the moment of decision, the potential for noncompliant behavior based on these beliefs is very present, while the chance seems remote that pilots may anticipate post-decision regret for not calling for a go-around — and may have that anticipation inhibit their tendency to continue the unstable approach.

Consider the psychosocial factors affecting unstable approach pilots at the time they need to make an appropriate decision on whether to go around: They have a lowered sense of situational awareness across most facets, which has led them to minimize the importance of objective threats in their assessment of risk. Further, their decision-making process receives little help from protective crew norms and processes; and there is no real disincentive to fly unstable approaches,

2 V_{REF} is reference landing speed

Figure 1

GA Thresholds for Flight Path Deviation

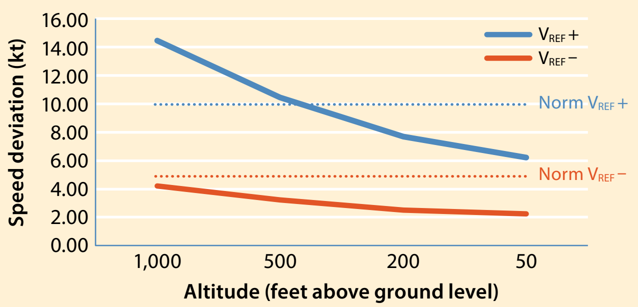


GA = go-around; LFPD = lateral flight path deviation;
VFPD = vertical flight path deviation

Source: The Presage Group for Flight Safety Foundation

Figure 2

GA Thresholds for Velocity Deviation

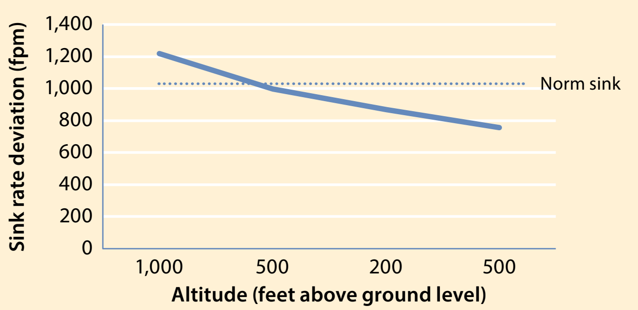


GA = go-around; V_{REF} = reference landing speed

Source: The Presage Group for Flight Safety Foundation

Figure 3

GA Thresholds for Sink Rate Deviation



GA = go-around

Source: The Presage Group for Flight Safety Foundation

considering the expected company response to that decision. These are the ingredients of a recipe for the "normalization of deviance" to contaminate this component of aviation safety culture. Essentially, this term refers to the development of a "new normal" mode of operation, which is passively supported, tolerated and/or approved by its stakeholders (pilots), owners (company management), and in some cases, regulators. Once entrenched within a given culture, this new mode's power and authority can considerably influence behavior, as evidenced in the Challenger and Columbia space shuttle tragedies (Vaughan). Supportive evidence from the results of this study indicates that in their acceptance of the noncompliant normal, unstable approach pilots have surrendered a level of situational awareness competency that directly impacts accurate risk assessment and full compliance with SOPs as published. In short, new norms, roles and incentives have come to displace some of the influence that situational awareness should have in proximity to risk assessment and decision making.

5.4.3 Pilot Thresholds for Going Around

Another area for discussion is the second experimental part of the survey, which asked pilots to describe their risk tolerance thresholds for various in-flight parameters, given a set of flight and environmental conditions. We found that braking action (good vs. poor) had a particularly large impact on a pilot's perception of the degrees of instability that warrant calling for a go-around. On the whole, however, pilots' thresholds for calling for go-around varied as a function of both height AGL and the instability parameter they were considering as a reason for going around. For several of these instability factors, the perceived threshold occurred well below 1,000 ft AGL (Figures 1 to 3). In particular, pilots said that they should be on profile at roughly 800 ft AGL, and that they could compensate for instabilities for V_{REF+} and sink rate later in the decent, at around 500 ft AGL.

In another project analysis, combined data from six North American airlines (two international jet airlines, three regional jet airlines and one regional turboprop airline) that are studying this problem independently show 2,035 pilot responses to the question: "What is the lowest altitude you believe a safe go-around could be executed from; with variable conditions?" (Figure 4, p. 18; Figure 5, p. 19; Figure 6, p. 20; Presage Group). The results can be broken out into four groupings: lateral and vertical deviations, energy management, aircraft configuration and environmental conditions. From the data, we can see significant altitude differences between the configuration of the aircraft and energy management, and how the more challenging environmental conditions affect flight crews' outlooks about when a go-around should be performed. Also of note is the lower altitude at which flight crews feel comfortable performing a go-around when all conditions are normal; this is not surprising, as we

Figure 4

Pilot Response Scores to Question: What is the lowest altitude you believe a safe go-around could be executed from? (With variable conditions. Segmented values.)

	1,000 ft	500 ft	200 ft	100 ft	Threshold Crossing	Just Prior to Reverser Thrust Deployment
You are laterally slightly more than 1 dot away from centerline approach course	11%	33%	23%	14%	14%	4%
You are vertically slightly more than 1 dot above desired glide path	9%	27%	22%	12%	24%	6%
You are vertically slightly more than 1 dot below desired glide path	15%	34%	23%	15%	10%	4%
Your airspeed is V_{REF} plus 20–25 kt	13%	30%	19%	10%	21%	7%
Your airspeed is V_{REF} minus 0–5 kt	5%	22%	22%	18%	27%	7%
Your vertical rate of descent is slightly greater than 1,000 fpm	12%	39%	26%	11%	9%	3%
Thrust is at idle	11%	32%	21%	10%	16%	10%
The aircraft is not fully configured for landing (gear/flaps)	38%	43%	7%	3%	6%	2%
The aircraft is unstable by parameter(s) you feel are most critical and the landing distance available is the required distance plus 10%	22%	39%	15%	8%	11%	4%
The aircraft is unstable by parameter(s) you feel are most critical and the landing distance available is the required distance plus 100%	18%	31%	18%	9%	16%	8%
The aircraft is unstable by parameter(s) you feel are most critical and the runway braking action is poor	31%	34%	12%	7%	10%	6%
The aircraft is unstable by parameter(s) you feel are most critical and the crosswind is slightly more than 30 kt	21%	37%	17%	9%	12%	4%
The aircraft is unstable by parameter(s) you feel are most critical and the tail wind is slightly more than 10 kt	22%	33%	18%	9%	13%	5%
You are stable and all environmental conditions are good	3%	15%	13%	11%	37%	21%

V_{REF} = reference landing speed

Note: Some rows do not total 100% because of rounding.

Source: The Presage Group for Flight Safety Foundation

instill through training and demonstration that a go-around is safely accomplished up to the point of thrust reverser deployment.

5.4.4 Varying Objective Levels of Unstable Approach Risk

A full analysis of the objective levels of risk in each event recalled by the pilots is warranted to fully explain the phenomenon of broad noncompliance with go-around policies and SOPs. The inherent risks associated with the 97 percent of unstable approaches that continue unstable can only be indirectly inferred from the present methodology, based on pilot self-reports. This study mainly assessed the psychological characteristics and attributes, *in situ*, of pilots who choose to continue unstable approaches to landing versus those who make decisions to go around. The study does not segregate the various unstable approach scenarios into classes of environments presenting high or low objective risks. While it is understood that not all unstable approaches carry the same level of inherent risk, the 97 percent of unstable approaches that are flown to completion include the highest-risk approaches, and these can result in accidents. In the absence of a definition of the objective level of risk associated with a given approach, pilots have only one set of criteria, one definition of the instabilities and environmental threats that are expected to trigger a go-around choice. Beyond this single definition, it is up to the pilot to further determine

Figure 5

Pilot Response Scores (Cumulative) to Question: What is the lowest altitude you believe a safe go-around could be executed from? (With variable conditions. Cumulative values.*)

	1,000 ft	500 ft	200 ft	100 ft	Threshold Crossing	Just Prior to Reverser Thrust Deployment
You are laterally slightly more than 1 dot away from centerline approach course	11%	45%	68%	82%	96%	100%
You are vertically slightly more than 1 dot above desired glide path	9%	36%	58%	70%	94%	100%
You are vertically slightly more than 1 dot below desired glide path	15%	48%	72%	86%	96%	100%
Your airspeed is V_{REF} plus 20–25 kt	13%	43%	72%	82%	93%	100%
Your airspeed is V_{REF} minus 0–5 kt	5%	27%	49%	67%	93%	100%
Your vertical rate of descent is slightly greater than 1,000 fpm	12%	51%	77%	88%	97%	100%
Thrust is at idle	11%	43%	63%	73%	90%	100%
The aircraft is not fully configured for landing (gear/flaps)	38%	81%	88%	92%	98%	100%
The aircraft is unstable by parameter(s) you feel are most critical and the landing distance available is the required distance plus 10%	22%	62%	76%	84%	96%	100%
The aircraft is unstable by parameter(s) you feel are most critical and the landing distance available is the required distance plus 100%	18%	50%	67%	76%	92%	100%
The aircraft is unstable by parameter(s) you feel are most critical and the runway braking action is poor	31%	65%	77%	84%	94%	100%
The aircraft is unstable by parameter(s) you feel are most critical and the crosswind is slightly more than 30 kt	21%	58%	75%	84%	96%	100%
The aircraft is unstable by parameter(s) you feel are most critical and the tail wind is slightly more than 10 kt	22%	55%	73%	82%	95%	100%
You are stable and all environmental conditions are good	3%	18%	31%	42%	79%	100%

V_{REF} = reference landing speed

*Cumulative values may be affected by rounding.

Source: The Presage Group for Flight Safety Foundation

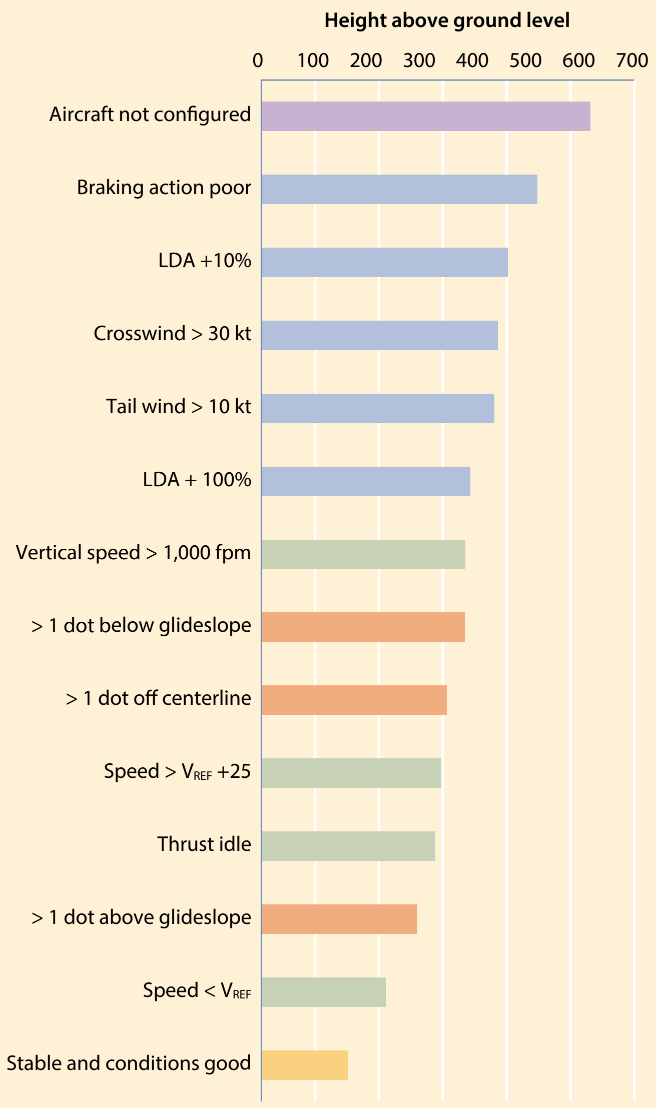
what he or she perceives as a safe and manageable level of risk. This determination flows directly from his level and type of situational awareness and the mental models of risk he constructs based on that awareness. To the extent that a pilot has lowered situational awareness — whether caused by acute aspects of the situation such as a high workload or chronic aspects of the cultural environment such as lessened acceptance of the company's go-around policy guidance or generally few challenges to cockpit command — he will be less sensitive to relevant situational awareness cues and therefore be more likely to continue an unstable approach irrespective of the inherent objective risks associated with the approach. These inadequately informed mental models of risk less accurately and sensitively represent the objective levels of the present threat. As a result, they will not track reality and will tend to produce an over-occurrence of noncompliant decision making.

5.4.5 Complete Prescriptive Policies vs. Predominately Prescriptive Policies

Complete prescriptive go-around policies and SOPs lend themselves to one set of criteria — one definition of the instabilities

Figure 6

Pilot Response Scores (Average) to Question: What Is the Lowest Altitude You Believe A Safe Go-Around Could Be Executed From? (With variable conditions. Segmented values.)



LDA = landing distance available; V_{REF} = reference landing speed

Source: The Presage Group for Flight Safety Foundation

and environmental threats that are expected to trigger a go-around choice. A single set of criteria is often insufficient to cover all eventualities, however.

As Tony Kern, an aviator, psychologist and author of several books on human behavior, has said, guidance is effective when it is "well thought out and fair, written clearly, explained thoroughly, commonly understood and voluntarily complied with."

Too many rules lead to cynicism and noncompliance, and, because not all situations can be anticipated, rules cannot be developed to cover all possible developments; in these cases, the human ability to adapt to changing situations is just as important as the implementation of effective policies and procedures.

"We need to reach a point where two types of professional discipline become second-nature habits," Kern said. "The first is the *organizational discipline* to keep the [bad] rules to an absolute minimum and enforce the [good] rules across the board. The second is the *personal discipline* to comply [with company policies]."

Too often, he said, policies and procedures conflict with cultural norms, and when that happens, "anyone who studies noncompliance knows that culture will nearly always trump policy, at least in the long run." (Kern)

Not all unstable approaches carry the same level of inherent risk, and based on the different objective environments from approach to approach, there can be a conflict between these and the singular prescriptive company go-around policy, as indicated by the pilots' disagreement with company go-around policy thresholds. Once a pilot is outside the prescriptive box of go-around policy and has made the decision to continue the approach, he is left to his individual risk assessment method, whatever that may be, to determine his personal risk threshold, without guidance. Robust prescriptive policies that allow for some guided, open analysis of risk and decision making can offer a solution to these cases in which the objective environment and stated policies do not align well.

For example, if a company's go-around policy says that a flight crew must go around in all cases if the aircraft has not touched down within seven seconds of crossing the threshold, the pilots likely would view the importance of that policy differently, depending on the conditions of the day. They would likely be more in agreement with the policy for an approach to a shorter runway that was contaminated and had a slight tail wind than for an approach to a longer, dry runway with a slight head wind. If the policy is written to allow some deviation from the seven-second requirement, under some guiding principles, pilots will agree with the policy more often. In this example of the short contaminated runway, the pre-descent briefing should include a statement that there would be no modification of the seven-second rule, whereas in the case of the dry, long runway, the briefing may include an allowance to increase that timeframe to 10 seconds. It is important to emphasize that these allowances should follow a guided process laid out by the company, and that the policies remain predominately prescriptive. In this example, guiding principles may be that all crewmembers agree in advance of the modification, and that the landing distance available exceeds the landing distance required by a predetermined percentage.

By allowing some guided decision making, pilots will be more likely to trust and voluntarily comply with written policies, in part because those policies will address the highly variable environments in which pilots work and also because the pilots will recognize that their expertise and real-time knowledge are being used in the risk-assessment process. An increased agreement on policy leads to increased buy-in and to the normalization of compliance.

5.4.6 Stable Approach Criteria, Gates, Callouts and Decision Points

It is also worth discussing the relationship between the stable approach criteria, the SAH targets, gates, safe landing guidelines and decision points. As the decision to go around remains possible up until the point of thrust-reverser deployment and go-around policies usually indicate that a go-around should be initiated any time an aircraft becomes unstable below the SAH, then it follows that the decision point to go around defines the beginning of a zone in which a go-around is mandatory if the approach is unstable; thrust reverser deployment defines the end of that zone. Most SOP callouts, however, channel flight crews to specific decision points to determine if they are in a state in which it is safe to continue the approach; these points are before thrust-reverser deployment. These SOP callout points are usually linked with SAHs, leaving no formal stable callouts for an extended period of time when a go-around is viable. Active calls (a selection of calls that are mandatory for all varying objective conditions) force communication between pilots. Passive, or conditional calls, on the other hand, are only communicated if stimulated by a condition. The weakness in the passive call process is that, if a call is not made, it could be for reasons other than the required objective condition being present. For example, if a crewmember did not see the condition, a call would not be made; in addition, a crewmember might choose not to make a call for varying reasons, such as a subjective interpretation of the condition or fear of the cockpit authority structure. Active calls are always made, and, as stated, they force communication; their absence indicates another problem, such as pilot incapacitation.

Many responsive callouts by the pilot flying at SAH or minimum approach height suggest what will happen, what they are going to do — for example "Landing." Suggestive calls like this, to a degree, influence the decision to land and close the window for the decision to go around, even though a go-around may be required if the flight becomes unstable very late in the approach or landing.

Repeated and escalated calls allow a condition to remain alive in the conscious mind of the pilot; on the other hand, a single callout — for example at SAH — raises situational awareness about the condition at that moment. As situational awareness is dynamic, it can change quickly, improving or worsening, and callouts that are designed to continue as long as the condition exists help to maintain awareness of that condition; escalation of the calls can heighten awareness. Take the example of callouts from Enhanced Ground Proximity Warning Systems (EGPWS) and other terrain awareness and warning systems (TAWS). The system alerts the flight crew to a pending condition and continues with callouts until the condition is no longer present. The same effect can be accomplished in unstable approach callouts by both crewmembers and automated systems.

As the onset of approach instabilities can occur at any time, even late in the landing phase (Burin, Keys to a Safe Arrival), the window for a go-around decision follows; that is, the decision is not made at a defined point at the SAH. The decision points for a go-around are separate and distinct from the stable approach window, and as such, procedure designers can separate the two to maximize go-around decision making.

In reviewing the FSF ALAR Task Force "Recommended Elements of a Stabilized Approach" (Flight Safety Foundation ALAR Task Force), we discover a somewhat conflicting message. It states that approaches in instrument meteorological conditions (IMC) must be stabilized before reaching 1,000 ft AGL. (In visual meteorological conditions [VMC], they must be stabilized before 500 ft AGL in precision, nonprecision and visual approaches alike). On the other hand, the document indicates that descent below 500 ft is acceptable in maneuvering for a circling approach, and specifies that "wings should be level on final when the aircraft reaches 300 ft above airport elevation." In other words, on a precision guided approach, the documented guidance is that the aircraft must be stable on final no later than 500 feet AGL in VMC, and on a circling non-guided approach, the aircraft must be stable on final no later than 300 feet AGL. It is not difficult for a pilot to conclude that, if it is acceptable and safe to fly off a final approach profile until 300 ft AGL on a non-instrument approach, then it is also safe to fly an instrument-guided approach to 300 ft off profile, although that is, by definition, unstable.

5.4.6.1 Objective Monitoring/Feedback

Objective monitoring/feedback is that which does not require an individual to interpret information based on his or her experience or opinion; it is usually factual information. Objective feedback in the cockpit minimizes the need for interpretation and can lead to more consistent and faster decision making. Additionally, stating a fact — instead of interpreting information, making a judgment or forming an opinion — helps minimize the effect of a steep authority gradient in the cockpit, such as may exist when a low-time first officer is paired with a high-time captain. An example of objective feedback is that given by an automated system such as EGPWS. In this case, there is little subjective analysis done by the pilot when responding to automated callouts, and the response can be quick and predictable. This is, in part, why an automated energy management/unstable approach monitoring and alerting system can be very effective in improving go-around compliance. Another example of the use of objective feedback is the use of radio altimeter automatic callouts rather than interpreting radio altimeter readout information. Readouts can fluctuate due to terrain variances, and must be observed and evaluated. Callouts, on the other hand, are only heard; in the absence of an automated energy management system, after pilots cross the threshold, they usually subjectively interpret, or sense, how much runway has passed by, or how much remains. From this, they decide whether to conduct a go-around. If the pilot monitoring (PM) times the threshold crossing and then makes a procedural call at the point where touchdown should occur or a go-around should begin, this call constitutes objective feedback to the pilot flying (PF) and makes clear that something — either touchdown or a go-around — should occur (or should have occurred, driven by policy and SOPs).

Minimizing subjectivity in go-around decision-making procedures is an objective that procedural designers should make every effort to achieve.

5.5 Analysis: Management Decision Making

5.5.1 Overview of Results

In Table 8, we present data for managers' self-reports of their awareness of, and, if possible, their specific estimates of, both the industry's and their own companies' rates of compliance with unstable approach–go-around policy.

When asked whether they knew what the industry-wide compliance rate was, only 32 percent of managers said that they did. Of those who claimed awareness, however, fewer were willing to estimate a rate. Thirty-four managers (27 percent of the 128 participating) offered an estimated rate, which averaged 20 percent compliance (seven times the true rate) and was highly variable (range: 1 percent to 80 percent; standard deviation: 24 percent). Only one in seven managers (16 percent) reported a rate that was considered "accurate" (within 10 percent of the actual 3 percent industry-wide rate). The perception of industry-wide rates may not be the central concern of managers working to police their own noncompliance with unstable approach–go-around policy, but this general lack of awareness and accuracy in estimating the true rate, even among those claiming awareness, cannot be overstated.

When asked whether they knew what their own company's compliance rate was, 45 percent of managers said that they did, although only 42 percent offered an estimate of that rate. Thus, a majority of managers are largely unaware of unstable approach–go-around compliance and noncompliance rates, even within their own companies. Of the 54 managers who offered estimates, the mean rate was 34 percent compliance, again with a large range (0 to 100 percent) and standard deviation (35 percent). These managers are estimating compliance rates at their companies that are, on average, more than 50 percent above the industry average as they perceive it (20 percent). If their estimates were accurate, they would indicate that the managers' companies were outperforming the industry as a whole by more than tenfold (34 percent vs. 3 percent). What is most striking is the tremendous degree of variability in the data, revealing that there is very little common basis of perception, even among those claiming knowledge of the rates at their own airlines. In our view, it is highly unlikely that this is an objective estimate. For perceptions to have truly tracked with reality, these data would mean that companies are exhibiting the full range of compliance from zero to 100 percent. It is hard to imagine that this is the case, and hard to imagine how this could result in an industry-wide average that hovers at 3 percent year after year.

Table 8

Manager Self-Reports of Awareness and Levels of UA-GA Policy Compliance

	Perceived Rates of Compliance with UA-GA Policy		
	For the Industry	For Their Company's Flight Operations	As Indicated by Their Company's Flight Data Analysis Program
Awareness of rate:			
% Claiming knowledge of each rate	32	45	NA
% Reporting a rate	27	42	47
Distribution of perceived rate of compliance:			
0–<10%	16	15	12
10–<50%	7	12	14
50–100%	4	15	21
Unaware/Did not answer	73	58	53
Mean perceived rate of compliance (among those reporting)	19.6% sd = 24.4%	33.9% sd = 34.7%	44.3% sd = 37.4%

GA = go-around; NA = not applicable; sd = standard deviation; UA = unstable approach

Source: The Presage Group for Flight Safety Foundation

Almost all companies (91 percent) had a flight data analysis (FDA) program. Of the 116 managers at those companies, 54 (47 percent) reported on their rate of compliance as indicated by their data. These 54 managers are not the same 54 who reported on their companies' flight operations compliance rates in answer to the prior question. One in eight managers (12 percent) reported FDA–based compliance rates broadly in line with the industry average (i.e., less than 10 percent). At the opposite end of the spectrum, 21 percent reported rates above 50 percent. The mean rate was 44 percent, again with a wide range and variability (zero to 100 percent, with standard deviation of 37 percent). That such a spread of compliance rates is reported by this sample is surprising; we believe it reflects not only a general lack of awareness among managers of the rates of compliance with their own policies (as strongly indicated by the incidence of non-reporting) but perhaps also specific errors within their knowledge, although objective data are available. This assertion can only be made, however, by again assuming that compliance rates exceeding 50 percent are rare in the industry; we cannot rule this out because although we have access to self-reported data, we lack objective verification of company compliance rates. If the self-reported rates are accurate, it suggests that our sample is drawn from an unusually compliant subsample of companies. In that light, the lack of awareness effects across the manager study suggests that industry-wide awareness could be less than estimated.

We begin with some overall observations about the data in Table 8. First, on each of the three questions, the normative response is to not know, and only a minority of managers claim to know, or report, a rate of compliance. Second, as expected, managers claim, and report, compliance rates for their own companies more frequently than they do for the industry as a whole, probably because they are less familiar with industry-wide data. Third, their perception of the industry-wide compliance is out of line with reality, six times greater than the actual 3 percent rate of compliance. Fourth, managers tell us as an aggregate sample that they believe their companies are outperforming the industry's rate of compliance by 50 to 100 percent, on average; this is the equivalent of a compliance rate at least 10 times greater than the industry's as a whole. Finally, if we assume that these companies have a more realistic unstable approach–go-around policy compliance rate below 10 percent (i.e., a rate span still up to three times better than the current industry norm), this would mean that only about one in seven managers (12 to 17 percent) in the survey reported an accurate rate for their own companies, whether their reporting was based on a personal estimate or on their FDA data. If we give them more "compliance credit," and allow that their companies actually achieved rates upward of 50 percent, then a high accuracy of managers' rates of report is still shared by fewer than one-third of the sample: Seven in 10 simply do not know their own rates, or if they do know, they over-report their compliance rates by more than 50 percent. These kinds of perceptual errors are likely to produce overconfidence and complacency about mangers' unstable approach–go-around policy compliance.

5.5.2 Manager Situational Awareness Profile

5.5.2.1 Manager Perceptual Measures of Situational Awareness

Managers completed 17 questions to assess their attitudes, beliefs and behaviors concerning their company's go-around rates and unstable approach–go-around policies. The results are in Table 9 (p. 24).

First, the responses were subjected to an empirical factor analysis to determine how they merged in managers' minds and to provide simpler summary categories for presentation and discussion. Three of the four factors to emerge had more than one associated question. One factor (Factor 4) was a single-question assessment of behavior, namely, whether the respondent debriefed flight crew who had violated the company's unstable approach–go-around policy.

Factor 1's theme was the perceived support that the respondents received from their companies in understanding and managing go-around rates. The six questions this factor comprised were averaged and called "perceived support." Factor 2 comprised questions assessing the degree to which managers thought that their companies' unstable approach–go-around policies and procedures and their associated operational definitions were effective, clear and appropriate. Responses to five questions were averaged to create an index of "perceived effectiveness." Finally, Factor 3 was an expression of managers' concerns about and sense of urgency surrounding their companies' go-around rates. It was formulated by averaging responses to the five questions shown in Table 9, and named "perceived threat."

In addition to the four factors, we present overall measures recorded by managers of their satisfaction with, and the perceived effectiveness of, their companies' go-around policies and procedures, as they relate to unstable approaches.

The first thing to notice in Table 9 about these manager perceptions is the absolute levels of the means on the underlying six-point scale. (This six-point scale did not offer a midpoint, but instead presented the opportunity to report slight, moderate or strong agreement or disagreement with each statement or assertion; the midscale is 3.5 on this 1 to 6 Likert scale. [A Likert scale is a self-reported quantitative assessment that presents psychologically ordered categories in a meaningful way, such as on a scale from "strongly support" to "strongly oppose."]) An examination of the means on both the factor

Table 9

Psychosocial/Perception Results for Managers

	Overall Sample n=128 Means[1]	Report of FDA Compliance Rate: 0 - <10% "Correct" n=14 Means[1]	Report of FDA Compliance Rate: 10 - 100% "Incorrect" n=40 Means[1]	Segmentation: High Risk Perceivers n=45 (35%) Means[1]	Segmentation: Low Risk Perceivers n=83 (65%) Means[1]	
Factor 1: Perceived Informational/Organizational Support for Understanding/Managing Company's GA Rate						
There is a collective agreement within our department that the way we manage our go-around rates increases flight safety.	4.88	4.57	5.08	4.34	5.17	*
I have access to all the information required to help me understand our company's go-around rates.	4.41	5.00	4.75	4.24	4.51	
I have the support of my superiors in managing the go-around rates of our company.	5.06	5.00	5.10	4.56	5.35	*
I find solutions to compensate for any inability of our company to effectively manage go-around rates.	3.75	3.43	3.54	3.45	3.91	*
I feel comfortable approaching our senior management on any issues regarding how we manage our go-around rates.	5.10	4.93	5.28	4.57	5.39	*
There is no real desire to improve our company's go-around rates, either presently or in the future.[2]	*2.51*	*2.64*	*2.43*	*2.69*	*2.41*	
Index of perceived support (6-questions; Cronbach α = 0.57[3]; high scores=high support)	4.64	4.55	4.70	4.31	4.82	*
Factor 2: Perceived Clarity/Appropriateness/Effectiveness of Company's UA-GA Definitions, Policies/Procedures						
Our company's definition of when to initiate a go-around, while perhaps conservative, is there to ensure everyone's safety.	5.25	5.29	5.28	4.73	5.54	*
Our standard operating procedures are very well defined with respect to when to perform a go-around.	5.35	5.36	5.20	4.93	5.57	*
The design of our go-around policies is effective in managing our go-around rates.	4.46	3.93	4.58	3.49	4.96	*
Our company's definition of a "stable" approach is too narrow.[2]	*2.30*	*3.07*	*2.33*	*2.98*	*1.93*	*
Our company's procedures regarding when to initiate go-arounds are not realistic.[2]	*2.22*	*3.14*	*2.13*	*3.16*	*1.72*	*
Index of perceived effectiveness (5-questions; Cronbach α = 0.70[3]; high scores=positive view)	4.93	4.47	4.96	4.20	5.30	*
Factor 3: Perceived Threat Inherent in Company's GA rates						
I feel a sense of urgency to act on our company's go-around rates.	3.06	4.36	3.18	4.20	2.41	*
I am anxious about the company's management of our go-around rates.	2.56	3.50	2.51	3.60	1.96	*
Our company needs a better plan for corrective action to manage and improve our go-around rates.	3.29	4.36	3.40	4.60	2.56	*
My management experience tells me that our go-around rates are not a significant flight safety issue for this company.[2]	*3.57*	*2.29*	*3.45*	*2.69*	*4.05*	*
The way we manage our go-around rates does not compromise flight safety.[2]	*4.38*	*3.79*	*4.41*	*3.44*	*4.90*	*
Index of perceived threat (5-questions; Cronbach α = 0.78[3]; high scores=high threat)	3.02	4.03	3.08	4.05	2.42	*
Factor 4: Response to Flight Crew Noncompliance With UA-GA Policies and Procedures						
I debrief all flight crews who have broken our company's policies on operational procedures for go-arounds.	3.81	3.64	3.62	3.16	4.19	*
Overall Measures						
Overall measure of perceived effectiveness of GA policies and procedures (as they relate to unstable approaches)	4.42	3.93	4.58	3.51	4.92	*
Overall measure of satisfaction with compliance rate with flight operations' GA Policies	4.12	3.50	3.98	3.00	4.72	*

FDA = flight data analysis; GA = go-around; n = number; UA = unstabilized approach

Notes:

1. Means range from 1 (strong disagreement with an item's assertion) to 6 (strong agreement).
2. Questions in italics are reverse-worded; means on these are expected to be at the opposite end of the scale compared with regular questions.
3. Cronbach *α* is a measure of the internal consistency reliability of each index, ranging from 0.0 to 1.0.

*Asterisks indicate statistically reliable differences at $p < 0.05$ (one-tailed) between means in the two preceding columns. A *one-tailed test* is a method of gauging the statistical significance of a particular trait; *p* represents probability.

Source: The Presage Group for Flight Safety Foundation

indexes and the underlying questions reveals that managers perceive a moderate degree of effectiveness of their policies and procedures and slightly less than a moderate level of support from their organizations in managing their go-around rates. The overall measure of perceived effectiveness was slightly weaker than the index score of effectiveness; overall satisfaction with compliance rates associated with their flight operation's go-around policies, while slightly lower, was still on the positive side of the scale. In concert with this pattern — perhaps *because* of these perceptions and judgments — managers slightly disagreed overall (perceived threat) that there was a cause for concern or a need for action to improve their go-around rates.

Taken together, these absolute scores indicate that managers are not completely happy with their companies' performance on go-around policy and procedures, but their concerns are not great enough, seemingly, to stimulate greater awareness or action.

As an aside, a regression analysis of the drivers of the "overall effectiveness" and "overall satisfaction" scores revealed that overall effectiveness is perceived in proportion to scores on the Perceived Effectiveness Index, and to a lesser degree, the lack of urgency and concern is expressed by scores on the Perceived Threat Index. In complementary fashion, overall satisfaction was driven first by lower perceived threat scores and secondarily by higher perceptions reflected in the Perceived Effectiveness Index. These meaningful, differential patterns were observed, although the overall measures of satisfaction and effectiveness were high.

Finally, managers, on average, narrowly agreed that they "debrief all flight crews who have broken our company's policies on operational procedures for go-around." Taken at its face, 37 percent disagree that all flight crews are debriefed, a high absolute number of managers who admit to less than complete debriefing protocols. However, while this may seem like a high percentage, the fact that the statement was phrased as "I debrief" as opposed to "our company debriefs" may account for the response.

To examine the relationships between positive perceptions of organizational support, compliance effectiveness, satisfaction and low concern with their go-around rates, we studied responses from only those managers who had reported on their companies' FDA-sourced go-around compliance rates — that is, of all those claiming knowledge of this information. We divided them into managers whose reports were generally close to the industry average of 3 percent, accepting anyone who reported a rate of less than 10 percent into a group we labeled "correct" (for reporting what looked like a reasonably accurate rate, compared with the industry base rate). All other managers reported compliance rates from 10 to 100 percent and were placed in a comparison group labeled "incorrect" (for reporting a compliance rate not likely to be accurate).

The results show that stating an "incorrect" rate of compliance is associated, at significant statistical levels, with higher scores on two of the five questions on the second factor of perceived effectiveness, the Effectiveness Index as a whole, and the overall, single measure of effectiveness (overall effectiveness). It is also correlated with lower scores on the Perceived Threat Index and four of its five component questions. While this pattern may seem obvious in hindsight, it makes the point that, independent of the level of support perceived for managing a company's go-around rates (there were no differences on the Perceived Support Index), the perception of the company's policies as effective and the threat as low may flow from a basic lack of realistic knowledge or appraisal of the go-around compliance rates. If this causal effect is true — that is, positive perceptions lead to low perceived threat — then what is clearly indicated by these data is the need for consciousness-raising about the industry norm of massive noncompliance, and dissemination of the managers' own companies' data identifying their internal rates of unstable approach–go-around policy compliance and noncompliance.

5.5.3 Segmentation Analysis

To determine whether the sample included types of managers whose views of their company's go-around compliance rate and performance were consistent with each other and also different from other identified groups, we conducted a traditional cluster analysis on this sample of managers (i.e., non-hierarchical, agglomerative K-means cluster analysis, based on Euclidean distances). Due to the small sample size, we generated just two groups to compare, and based the mathematics of this segmentation on a variety of responses given in the survey. This "basis of segmentation" consisted of the 17 perception questions and the two overall measures of effectiveness and satisfaction — all the measures presented in Table 9.

Not surprisingly, the resulting groups consisted of one whose members perceived a high risk in their go-around compliance rates (the "High Risk Perceivers" Group) and a second group whose members had a more moderate view (the "Low Risk Perceivers" Group). The 35 percent of managers who perceived high risk differed from the 65 percent of low-risk perceivers on almost all measures in the survey, and powerfully so, in both the statistical sense and the magnitude sense (the degree of statistical difference). Table 9 shows that on 17 of 19 measures, and on all three indexes, the High Risk Perceiver Group showed a pattern of higher concern and perceived threat, lower satisfaction with their companies' go-around compliance, lower perceived policy and compliance effectiveness and lower perceived support from the organization for managing go-around rates. They also reported lower rates of debriefing their noncompliant flight crews.

When we profiled these two groups on other measures collected in the study, we found interesting correlated effects. For example, high risk perceiver types tended to see their company compliance rates as slightly underperforming, relative to (perceived) industry norms, whereas low risk perceiver types reported that their companies were definitely outperforming the industry compliance rate. High risk types were more likely to claim that prior to the study, they had been aware of the industry rate and of their own company flight operations' rate of compliance. Interestingly, those in the High Risk Perceiver Group were more likely to report being in roles in which they had less power to effect change, more often saying they were able only to offer recommendations. Added to the fact that members of the High Risk Perceiver Group were three times less likely than those in the Low Risk Perceiver Group to say their compliance rates were between 50 and 100 percent — a suspect number — and more than four times as likely to say that their FDA showed their rate was between zero and 9 percent — a number more in line with industry norms — a picture emerges of a group whose members are more realistic and appropriately anxious and concerned about their companies' low rates of go-around compliance, but who perhaps have little voice or power within the company to change policy or procedures (which they see as more likely to be unrealistic) or to offer a new definition of what should constitute a stable approach (which they see as overly narrow).

How did these managers score on the Presage indices of situational awareness? This situation presents a clear instance of violation, via near-complete noncompliance, of most airlines' policies and procedures surrounding unstable approach–go-around performance rates and their management. As such, our metrics are likely to show low absolute scores, on a scale of 1 to 6, with 6 corresponding to high safety awareness. The first column of Table 10, which displays these scores for the overall sample, shows this to be the case; in no case does the absolute score on any of our awareness metrics exceed the midscale of 3.5. Safety awareness is low in all of the awareness areas assessed by our system.

Table 10

Presage Situational Awareness Construct Results for Managers

Situational Awareness Indices	Overall Sample n=128 Means[1]	Report of FDA Compliance Rate: 0–<10% "Correct" n=14 Means[1]	Report of FDA Compliance Rate: 10–100% "Incorrect" n=39 Means[1]		Segmentation: High Risk Perceivers n=44 (35%) Means[1]	Segmentation: Low Risk Perceivers n=82 (65%) Means[1]
Functional Awareness Index (knowing the performance metrics)	3.32	4.07	3.42	**	3.72	3.10
Hierarchical Awareness Index (knowing the procedures)	1.71	1.69	1.74		2.19	1.46
Task-Empirical Awareness Index (knowing the limits)	2.16	2.67	2.15	*	2.90	1.77
Critical Awareness Index (relying on experience)	2.95	3.96	3.01	*	3.84	2.41
Affective Awareness Index (having a gut feel for threats)	3.00	4.06	3.05	*	4.04	2.38
Anticipatory Awareness Index (seeing the threats)	3.08	4.11	3.14	*	4.19	2.42
Compensatory Awareness Index (adjusting to threats)	3.02	3.45	3.01	**	3.59	2.71
Relational Awareness Index (keeping each other safe)	2.34	2.54	2.36		2.90	2.03
Environmental Awareness Index (corporate support for safety)	2.28	2.66	2.22	*	2.92	1.93

FDA = flight data analysis; GA = go-around; n = number; UA = unstabilized approach

Notes:

1. Means range from 1 (low awareness of UA-GA threat) to 6 (high awareness).

*A single asterisk indicates statistically reliable differences at $p < 0.05$ (one-tailed) between means in the two preceding columns. A *one-tailed test* is a method of gauging the statistical significance of a particular trait; *p* represents probability.

**Two asterisks indicate statistically reliable differences at $p < 0.10$ (two-tailed) between means in the two preceding columns. A *two-tailed test* is another method of gauging the statistical significance of a particular trait; *p* represents probability.

Source: The Presage Group for Flight Safety Foundation

Because we know in this instance that unstable approach–go-around noncompliance is a major problem for the industry, our measures of situational awareness are scored higher when this problem is recognized to be present. In the approach to scoring shown in Table 10, all measures are scored such that higher numbers indicate a greater degree of realistic threat awareness and appraisal. As a result, higher situational awareness on our measures is associated with seeing the current threat to be real (high anticipatory awareness) and the procedural measures used to compensate for it to be inadequate (poorly adjusting to the threat). Managers with higher situational awareness see their current procedures as unrealistic and the definitions of instability as too narrow (high scores on knowing the procedures and knowing the limits). Their experience (critical awareness: high reliance on experience) tells them there is a problem, and they feel more anxious and eager to take action against this safety threat (higher gut feeling for threats). However, because a new plan is needed in the face of a general lack of appreciation of the threat to compliance in their organizations, higher awareness is also associated with a perception that their companies have little will to change, and are generally complacent about the SOPs in place to manage the threat (low relational and corporate support for safety). As a result, those with higher awareness also feel less support from — and a higher level of discomfort in approaching — senior management to broach the issue.

With this understanding of our scoring methods in mind, we examined the scores of the two groups — the managers who reported a compliance rate based on their FDA that was "correct" (less than 10 percent) versus those who overestimated the compliance rate (10 percent or more). We hypothesized that a more accurate awareness of the true, low rate of compliance would be associated with a heightened sense of awareness, perceived threat and anxiety, the felt need to compensate, etc. — all aspects of the situational awareness model. We predicted, therefore, that managers who were aware of the actual low rate of compliance with unstable approach–go-around policies at their airlines would receive higher scores on all nine of our metrics than their colleagues who were unaware, even if the magnitude of these scores was still low in absolute terms when compared to the scale range.

In Table 10, it can be seen that on seven of our nine metrics of situational awareness, the hypothesis that the go-around respondents would report greater situational awareness was supported at a level of statistical reliability of 90 percent or better; that is, if this experiment were repeated 20 times, we would observe the same differences in 18 of the replications. Only on "Knowing the procedures" and "Keeping each other safe" were the levels of awareness similar for the two groups, albeit at low absolute levels. In summary, those aware of the low compliance rates at their companies scored at or above the midscale on five of our metrics (Functional, Critical, Affective, Anticipatory and Compensatory). If a minimum midscale threshold of situational awareness across a majority of our measures was enough to trigger some action, the individuals in this group were close to reaching such a trigger point. However, note that this group constituted just 11 percent (14 of 128) of our sample — a small minority coming to full awareness of the problem.

Table 10 also shows results derived from cluster analysis on the Presage metrics for the two groups — those perceiving relatively high risk in their companies' unstable approach–go-around policies and rates (35 percent of sample) and those not generally perceiving such risks (65 percent). (It will be recalled these groups were designed for all managers in the sample, irrespective of whether they claimed to know, or ventured to report, what their company compliance rate actually was, according to FDA or otherwise). In this case, all nine awareness factors are statistically reliably different, with five means above the midscale for the high-threat perception group. These results are more encouraging in terms of "sizing" the complement of managers perhaps ready to act in this important area of noncompliance, as about one-third of the sample shows signs of having reached a threshold of awareness that will trigger activity to manage this issue more safely in the near future.

As a demonstration of the effect that improved awareness in one area can have on overall situational awareness, we compared the situational awareness scores of all managers (Figure 7, p. 28) with the scores of the group whose members were aware of their internal company go-around compliance rates (Figure 8, p. 28). Figure 8 shows the incremental benefit that awareness in one area can have across eight of the nine constructs.

Finally, it is relevant to discuss the industry's approach to monitoring unstable approach flight data. As many flight data monitoring programs are set to report only when more than one stable approach criterion is exceeded, and in some programs, to report only a low level alert until three or more criteria are exceeded, we see an indication from those responsible for the design of these programs that there is an acknowledged variability in the risk of unstable approaches, and, more importantly, there is an indication of a disconnect between the level of management's concern for low risk unstable approaches and the policy guidance for flight crews on those same approaches, which is to execute a go-around when one or more criteria are exceeded. From the perspective of the flight crews, why should they be concerned about the risk of this level of unstable approaches if management is not concerned enough to want to be told about them or act on

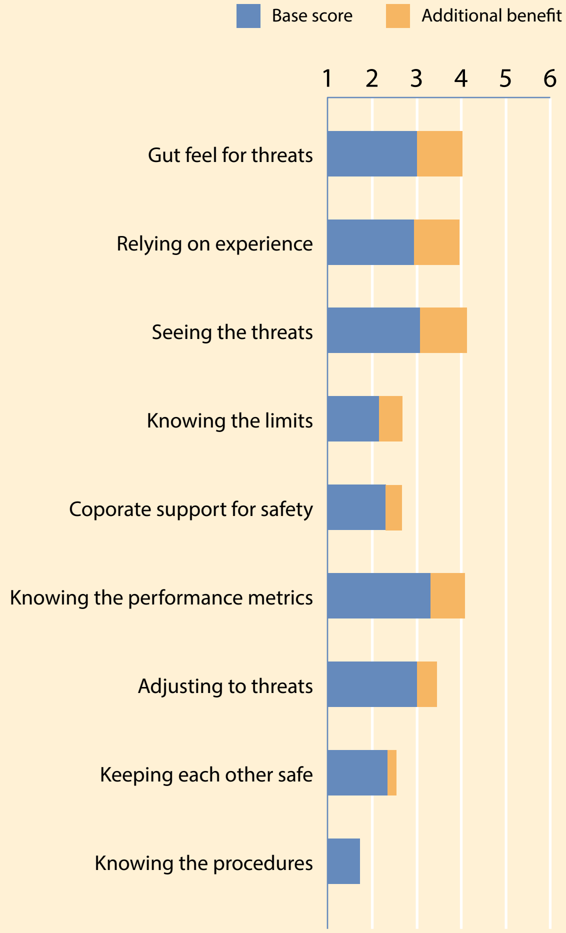
Figure 7

Overall Manager Situational Awareness Scores

Source: The Presage Group for Flight Safety Foundation

Figure 8

Situational Awareness of Managers Who Knew Company Compliance Rules



Source: The Presage Group for Flight Safety Foundation

them? This is consistent with the results of both the pilot and management psychological studies.

5.5.4 Industry Sensing

The conversation about reducing the risk of ALAs often drifts toward how to eliminate unstable approaches, even though the discussion begins with a focus on rates of compliance with go-around policies. It is clear that there is a larger discomfort with the existence of unstable approaches, despite the fact that the industry has reduced unstable approaches to 3 percent or less. In an industry with such variable objective environments, one must ask "What is the lowest attainable unstable approach rate?" It makes sense that an industry with almost nonexistent compliance with go-around policies would be concerned about the small number of unstable approaches that occur. If we turn the tables and consider for a moment an industry with a high rate of go-around policy compliance, would there be as much concern about unstable approaches? And is the focus on eliminating unstable approaches the right strategy in reducing ALAs? In Flight Safety Foundation's 16-year study of runway excursions, conducted in 2010 (Tarrel), we see that 53 percent of the landing excursions were classified as veer-offs, and of these, 66 percent followed a stable approach that became unstable during the landing phase. Only 37 percent of the landing excursions followed unstable approaches. Overruns accounted for the other 47 percent of landing excursions; 37 percent of overruns followed stable approaches, and 63 percent followed unstable approaches. In total, 52 percent of landing runway excursions followed stable approaches, and an almost-equal number — 48 percent — followed unstable approaches. A separate analysis by Boeing of runway overrun excursions from 2003 to 2010 found that 68 percent followed stable approaches. (Jenkins and Aaron). Drawing from this, a concentrated effort to reduce the number of unstable approaches that become unstable in the approach phase will address less than half of all landing excursions. On the other hand, a reliable go-around decision-making operation has the potential to affect most landing excursions — those occurring after flights that become unstable during the approach or landing phase. Clearly, a strategy to continue improving the stable approach rate in addition to improving the go-around compliance rate is the most complete strategy. The point of this discussion is to illustrate that the industry's tendency to focus only on eliminating unstable approaches will not address a large portion of ALAs, and that improving the go-around compliance rate holds the greater risk-reduction potential.

In 2009, an FSF runway safety initiative determined that a gap existed in *ALAR Tool Kit* risk reduction tools, which did not address the landing phase itself. The Foundation then developed *Safe Landing Guidelines* (Burin, Keys to a Safe Arrival), which are intended to be used by aircraft operators to enhance existing SOPs. Throughout this project, and through industry conferences and meetings, it was apparent that these guidelines were not well known or commonly documented in company manuals. These findings were not part of the data collection surveys.

5.6 Findings: Go-Around Decision Making

The following are decision-making findings (DM) drawn from analysis. *DMP* denotes decision-making pilot findings, and *DMM* denotes decision-making management findings.

DMP Finding 1. The unstable approach pilot group's gut feeling for threats — the "seat of the pants" experience characterized by an emotional, sensory experience that triggers further cognitive analysis — is lower than it is for the go-around pilot group.

DMP Finding 2. The unstable approach pilot group's ability to see and/or monitor real and potential threats as they change over time and space is lower than that of the go-around pilot group.

DMP Finding 3. The unstable approach pilot group is more likely than the go-around pilot group to minimize efforts to discuss instability and environmental factors with other crewmembers, and to shut themselves off from available resources.

DMP Finding 4. Unstable approach pilots are more tolerant than go-around pilots of deviations from operational limits and procedures.

DMP Finding 5. Unstable approach pilots are less compliant than go-around pilots with performing all checklist items and accurately completing standard calls.

DMP Finding 6. Unstable approach pilots minimize what their professional experience, or critical awareness, could offer in terms of executing known policies, compared with go-around pilots.

DMP Finding 7. Unstable approach pilots are more comfortable than go-around pilots with operating on the margins of safety, which translates into a greater tolerance of risk.

DMP Finding 8. Unstable approach pilots are more likely than go-around pilots to feel pressure to land or perceive a lack of support for a decision to go around.

DMP Finding 9. Unstable approach pilots are more likely than go-around pilots to feel discomfort in being challenged or challenging others.

DMP Finding 10. Unstable approach pilots are likely to feel inhibited about calling for a go-around in situations with a strong cockpit authority gradient.

DMP Finding 11. Go-around pilots indicated — four times more often than unstable approach pilots — that another crewmember was prompting the crew to initiate a go-around.

DMP Finding 12. Unstable approach pilots are less likely than go-around pilots to feel support for safety from their companies, and said they were less likely to be reprimanded for continuing an unstable approach to landing and more likely to believe that the incentive structure of their company does not discourage unstable approaches to landing.

DMP Finding 13. Unstable approach pilots believe that their company's criteria for unstable approaches are not realistic.

DMP Finding 14. Unstable approach pilots, in hindsight, feel regret about continuing an unstable approach more strongly than go-around pilots regret going around, and feel less positive about the outcomes of their decisions.

DMP Finding 15. Unstable approach pilots have a lower sense of situational awareness across most facets, which leads them to minimize the importance of objective threats in their risk assessments.

DMP Finding 16. Pilot norms and processes for continuing unstable approaches provide little foundation for compliant go-around decision making (i.e., the "normal" action is to *not* go around when unstable).

DMP Finding 17. Norms, roles and incentives have displaced some influence that good situational awareness should have in risk assessment and decision making.

DMP Finding 18. Pilots who believe that their company's criteria for unstable approaches are not realistic also believe, on a whole, that the threshold for the aircraft to be on profile and in proper configuration is below 1,000 ft — closer to 650 to 800 ft AGL.

DMP Finding 19. Pilots who believe that their company's criteria for unstable approaches are not realistic also believe, on a whole, that they can compensate for energy management instabilities until the aircraft descends to 500 ft AGL, and under certain conditions, below 500 ft.

DMM Finding 1. At the managerial level, there are indications of general disengagement with the topic of go-around policy and procedures.

DMM Finding 2. Among managers, there is a general lack of awareness of industry-wide rates of go-around policy compliance.

DMM Finding 3. Among managers, there is a general lack of awareness of their own company rates of go-around policy compliance.

DMM Finding 4. Among managers who have objective go-around noncompliance rate data, such as flight data, understanding of the compliance rate is likely inaccurate.

DMM Finding 5. Managers who claim to know the company go-around compliance rate are likely to overstate the compliance rate by over 50 percent. These perceptual errors are likely to produce overconfidence about go-around compliance.

DMM Finding 6. Managers perceive a moderate degree of effectiveness of their policies and procedures.

DMM Finding 7. Managers perceive less than a moderate level of support within their company for managing go-around compliance rates.

DMM Finding 8. Managers slightly disagree overall that there is concern about, or a need for, action to improve their go-around compliance rates.

DMM Finding 9. The managers with better understanding of go-around compliance rates for both the industry and their own companies, the High Risk Perceiver Group, were more realistic and concerned about their companies' low go-around compliance but perhaps have little voice or authority within the company to change policy or procedures.

DMM Finding 10. Managers who scored higher on the situational awareness measure associated with seeing the current threat as real (anticipatory awareness) also scored lower in relative terms on the measure used to compensate correctly for the risk (compensatory awareness), suggesting the presence of a "learned helplessness" with respect to effectively managing this risk.

DMM Finding 11. Managers with higher situational awareness scores see their current procedures as being unrealistic and definitions of instabilities as being too narrow.

DMM Finding 12. Managers with higher situational awareness scores had the perception that their companies have little will to change and are generally complacent about SOPs for managing go-around compliance.

DMM Finding 13. Managers with higher awareness of their companies' go-around compliance rates also feel less support from senior managers and a higher level of discomfort with approaching them about the issue.

DMM Finding 14. Managers who were aware of low go-around compliance rates in their companies scored at or above the midscale on functional, critical, affective, anticipatory and compensatory situational awareness metrics. This is a minority consisting of 11 percent of respondents.

DMM Finding 15. The industry's tendency is to lean toward the single focus of improving the unstable approach rate as the best way to prevent ALAs, even though empirical data indicate otherwise.

DMM Finding 16. *Safe Landing Guidelines*, published by Flight Safety Foundation to address an identified gap in the *ALAR Tool Kit* risk reduction tools, is not well known by operators and not documented in operations manuals.

5.7 Strategies for Corrective Action: Go-Around Decision Making

We conclude that there are three high-level categories that can be defined in achieving an effective policy from a psychological perspective:

- The policy should make sense operationally — for most environmental conditions encountered — for the people executing the policy (flight crews) and those managing the policy (flight operations management), and should be acceptable to those externally effected by the application of the policy (air traffic controllers).
- The policy must be managed effectively by the organization's management personnel. This is important not only because of the organization's need to achieve objectives set out by senior management but also because those executing the policy (flight crews) need to see and understand that the policy is being managed (i.e., management oversight of the policy is apparent).
- Awareness of the policy guidance and the risks associated with not executing the policy must be high for both flight crews and management.

The following is a list of recommended higher-level decision-making strategies to mitigate go-around noncompliance.

DM Strategy 1. Ensure the policy makes sense operationally.

a. Update the stable approach definition and SAH to maximize their relevance to flight crews and their manageability.

b. Separate the stable approach definition and criteria from decision-making criteria and decision-making points to improve awareness that these are two distinct aspects of go-around policies, and that decision making continues beyond the approach phase. This does not imply that they cannot meet at points throughout the approach and landing; it is intended for the SOP and communication designers to separate the psychological attachment of these two aspects.

DM Strategy 2. Manage the policy effectively.

a. Operators set specific compliance rate targets (key performance indicators) and establish initiatives to achieve them.

b. Authorities amend industry and regulatory audit programs to include standards and recommended practices that address go-around noncompliance.

DM Strategy 3. Increase awareness.

a. Increase awareness of go-around noncompliance and risks associated with continuing to land when unstable, and awareness of the significant impact that noncompliance has on ALAs, among:

   i. Operator management;

   ii. Flight crews;

   iii. Industry and pilot associations;

   iv. Regulators; and,

   v. Manufacturers.

b. Enhance situational awareness (psychosocial awareness) to heighten flight crews' awareness throughout the approach (SAH and beyond), and landing through:

   i. Policy and procedural enhancements; and,

   ii. Communication improvements.

c. Minimize the subjectivity of go-around decision making for the decision maker (e.g., PF or captain, as per company policy) to mitigate those components of situational awareness that compromise the pilot's risk assessment and decision-making ability, for example, by installing stable approach monitoring systems.

5.8 Recommendations: Go-Around Decision Making

The following are decision-making recommendations for corrective action to mitigate go-around noncompliance and go-around execution risks. Each recommendation supports a previously identified higher-level strategy.

DM Recommendation 1. Manufacturers should continue development of — and operators should install — stable approach and energy management monitoring and alerting systems.

DM Recommendation 2. Operators should understand their own respective go-around compliance rates.

DM Recommendation 3. Operators should establish internal go-around compliance rate measures, targets and goals.

DM Recommendation 4. Where necessary, flight crew associations and operator management should establish a basis, and/or process in which FDA can be used to assist in effectively managing go-around compliance targets.

DM Recommendation 5. Operators and the industry should re-define the stable approach criteria and SAH to better align policies with manageable and operational safe practices. See Appendix 10.3 for Flight Safety Foundation's *Analysis: New Stabilized Approach and Go-Around Guidelines, 2017* (proposed for industry validation).

- Avoid stable approach criteria and heights that address very low-risk approaches. That is, avoid criteria that, if exceeded, are not likely to result in a go-around decision, or that, if a go-around decision is made, may transfer risk to a higher-risk go-around maneuver
- Distinguish between profile criteria (vertical and lateral), energy management criteria and go-around decision point criteria, which could have distinct and separate heights.
- Allow for variable objective environments. Not all environments create the same risk profile. High crosswinds, tail winds and contaminated runways statistically create the highest-risk environments.
- The stable approach criteria, although mostly prescriptive, should allow an element of guided risk–assessed decision making that is corroborated between crewmembers.

DM Recommendation 6. Operators should establish and publish safe landing guidelines in operations manuals. (Burin, Keys to a Safe Arrival) (Curtis and Blajev). See Appendix 10.4 *Analysis: Revised Safe Landing Guidelines, 2017* (proposed for industry validation).

DM Recommendation 7. Operators should develop communication procedures to be performed during every approach that describes the state of stability and the intention of the decision maker, based on company policy. Effective elements of these communications include:

- The state of stability is made by the crewmember not responsible for the decision to go around (e.g., the PM or the first officer, per company policy). This creates a shared responsibility for activity in the decision-making process.
- Communication procedures are active, not passive or conditional (i.e., a call is made at the assigned point during every approach. This forces communication.

- Communication procedures should be objective (i.e., they should state facts about the condition. This minimizes authority gradients within the cockpit.
- Communication procedures should be sequential and escalate (i.e., if the condition is not corrected to within limits, active calls continue and escalate to a defined point at which a new directive call is mandated). For example, if an "unstable" call at 500 ft AGL does not result in successful corrective action, the "unstable" calls continue every 100 ft until the condition is corrected or a critical point is reached, and then a directive call is made (e.g., "go-around"). This maintains continuous situational awareness updating of the condition, similar to ground-proximity warning system (GPWS) calls.
- Active communication should continue well into the approach and landing (e.g., up to the touchdown limit point). This maintains continuous situational awareness.
- Each "stable condition" call should be answered with an acknowledgement or notice-of-intention call by the decision maker (the PF or captain, per company policy).
- The "intention" call should not suggest the exclusion of other possible outcomes (e.g., calling "landing" at minimums when a go-around is an option can have the effect of minimizing/compromising the window of calling for a go-around. On the other hand, responding with "Roger" or "Continue" assists in keeping decision making open.)

DM Recommendation 8. Operators should apply objective feedback/communication procedures well into the approach and landing phase, including in the touchdown zone. Energy management monitoring and alerting systems will minimize the need for crew-initiated calls.

DM Recommendation 9. Operators should create standard predescent briefing guidelines that include:

- Environmental risk factors;
- Instability factors that will result in a go-around;
- A review of standard calls; and,
- Decision making in the landing phase.

DM Recommendation 10. Operators should create standard preapproach briefing guidelines that update the pre-descent briefing at a low-workload period just before the approach is begun.

DM Recommendation 11. Operators should understand their respective managers' and flight crews' situational awareness levels and psychological profiles for managing internal go-around policies.

DM Recommendation 12. Operators should provide training to enhance psychosocial awareness and management, and how they contribute to noncompliant decision making.

DM Recommendation 13. Operators should ensure no fault go-around policies are documented, implemented and understood by management and flight crew.

DM Recommendation 14. Operators should ensure that unstable approach and go-around policies are concise and unambiguous, including follow-up procedures and expectations for noncompliance.

DM Recommendation 15. Operators should communicate industry rates and internal go-around compliance rates, measures, targets and goals of performance to flight crews and the managers involved in achieving them. Operators also should communicate the risk-reduction potential that improved performance could have on the company's overall risk profile.

DM Recommendation 16. State and industry audit programs, such as the IATA Operational Safety Audit (IOSA), should establish go-around compliance standards and recommended practices for operators to manage go-around compliance.

DM Recommendation 17. State and industry safety organizations such as those associated with the International Civil Aviation Organization (ICAO), the European Aviation Safety Agency, FAA, IATA, the FAA Commercial Aviation Safety Team (CAST) etc., should review these recommendations and assess inserting them into their safety publications.

DM Recommendation 18. The aviation community should annually track, through global aggregate flight data, go-around compliance rates for both the approach phase and the landing phase of flight, and communicate the findings to the industry. This role is suited to safety organizations such as Flight Safety Foundation.

DM Recommendation 19. The aviation community should develop and implement an initiative that communicates the industry's go-around compliance rate, and the risk-reduction potential that improved performance could have on the industry-wide ALA rate and the overall accident rate. This is a role suited to regulators, global associations and safety organizations such as Flight Safety Foundation.

DM Recommendation 20. The aviation community should establish a new information-sharing program to provide a method for operators to share effective strategies to improve go-around compliance rates. Alternatively, the information should be incorporated into an existing program.

DM Recommendation 21. The industry should establish an identifiable "label" for the threat/causal effect of the phenomenon of noncompliance with go-around polices. As labels such as controlled flight into terrain (CFIT) or loss of control (LOC) make it easier for the industry to relate, discuss, understand and manage a phenomenon, a label for this phenomenon will do the same, and in so doing, will help provide a foundation for essential awareness.

The effective utility of each recommendation is different, and each recommendation addresses a different finding or strategy, as can be seen in Appendix 10.2. A holistic approach to implementing these recommendations will have the best overall effect. And as with any significant program change, desired, and undesired, effects should be closely monitored by an appropriate audit program such as FDA, line operations safety audits, or IOSA.

6 Go-Around Execution

6.1 Methodology

The go-around accident and incident review included a non-random selection of published reports on go-arounds involving transport-category aircraft between 2000 and 2012.

A total of 64 go-around events were included. In some, the safety of the go-around was central to the investigation, and in others, the go-around occurred in the aftermath of the event at the heart of the investigation. The majority of the events (64 percent) involved single-aisle jets. Others involved twin turboprops (20 percent) and twin-aisle jets (16 percent). The nature of the sample — independently investigated events in which an approach was followed at some point by a go-around — meant that the sample group contained both safe and unsafe go-arounds. Sometimes the investigations focused on the circumstances that led to the go-around; sometimes they focused on the go-around itself, and sometimes they focused on both. Remarks contrasting the safe go-arounds with the risk-bearing go-arounds are, therefore, subject to the qualification that the safe ones were just a non-random subset of many more similar go-arounds that are routinely conducted because of both crew decisions and ATC instructions.

The context, safety aspects and overall level of risk of each event were shown on a spreadsheet, with as many of a selection of 185 "tags" as were applicable attached to each one. Not all tags were mutually exclusive, and not all reports allowed the applicability of all of the tags to be established. The extent to which many characteristics could be identified is, therefore, understated.

On the basis of the degree of risk posed by a go-around, each event was assigned to one of three categories — high risk (18 events), moderate risk (25 events) and non-risk-bearing (21 events). The non-risk-bearing events involved circumstances — some of which were similar to those of risk-bearing events — that were the main concern of the investigation.

For the two risk-bearing categories, six "headline" go-around safety issues (GASIs) were defined in respect to the initiation and execution of each go-around. Most of the 43 risk-bearing events involved a single GASI, but five events were assigned two GASIs each.

Each risk-bearing event was assigned one of three "outcome risks" — LOC, CFIT or midair collision (MAC).

The GASI definitions and their associated outcome risks were:

- AO1 — Initiation of go-around ineffective (LOC);
- AO2 — Safe trajectory of aircraft not maintained once go-around successfully initiated (LOC/CFIT);
- AO3 — Go-around not flown on required track (CFIT);
- AT1 — Safe traffic separation not maintained during go-around (MAC);
- AT2 — Wake turbulence hazard during go-around (LOC); and,
- EN1 — Significant low-level wind shear during go-around (LOC).

In the 79 percent (34) of risk-bearing go-arounds in which the risk was attributable to the mismanagement and/or mishandling of the go-around by pilots, failure to initiate a go-around effectively was twice as prevalent as the failure to aviate and navigate properly once the go-around was initially established.

In the 19 percent (8) of risk-bearing go-arounds in which the risk was attributable to air traffic controllers, the following conditions applied:

- One go-around followed controller failure to apply clearly established procedures in respect to a late go-around, which led directly to an unrecognized MAC risk resolved by a traffic-alert and collision avoidance system (TCAS) resolution advisory (RA).
- Five go-arounds involved controller misjudgments in dealing with the proximity of takeoffs to unexpected go-arounds — a significant loss of separation in four cases and an unrecognized wake turbulence hazard in the other. Two events involved controllers talking to different aircraft on the same frequency in different languages. In both cases, pilots seeking to understand the developing situation — both before and after the go-around began — were deprived of valuable situational awareness.
- Two go-arounds involved a single conflict between a pilot-declared go-around and a controller-instructed go-around in which a trainee controller under supervision in a non-radar environment was faced with an aircraft transitioning to a conventional go-around, and the resulting need to instruct the potentially conflicting aircraft, which was on a required navigation performance (RNP) approach, to fly an RNP go-around. The situational awareness of each flight crew — both on go-arounds in IMC — of the potential proximity of the other aircraft was compromised by lack of procedure awareness.

Decisions by pilots that were followed by poor initiation of a go-around and that led to hull loss accidents (accidents in which an airplane is destroyed, or damaged and not repaired, including events in which an airplane is missing or inaccessible) due to either LOC or CFIT were particularly likely to involve a crew in which either the pilot-in-command (PIC) or the first officer was lacking in experience. For the PIC, this lack of experience involved experience in either the aircraft type or the role of PIC.[3] For the first officer, it involved experience in the aircraft type or in multi-crew operations generally.[4]

In all events in which the experience of both pilots was fully documented, one or both pilots were low on experience, according to the above definitions, in:

- 80 percent of fatal/hull loss go-around accidents;
- 73 percent of all high-risk go-arounds;
- 64 percent of all moderate-risk go-arounds; and,
- 60 percent of all non-risk-bearing go-arounds.

Excessive confidence by the PM PIC that the PF first officer would achieve a timely stabilization of the approach led the PIC to delay takeover as PF. Often, by the time the PIC took the controls, the circumstances had become more complex and the chances of not properly initiating the go-around had increased.

Conversely, excessive confidence by the PM first officer that the PF PIC would achieve a timely stabilization led — in operating cultures that may not have addressed the effect of a significant relative experience gap between the first officer and the PIC — to a delayed or absent go-around call and, in some cases, to a near takeover or an on-ground takeover of control in order to make such a call.

The more-unsafe go-arounds are more likely than safer go-arounds to have been preceded by one or more of the following:

- Significant procedural noncompliance, which was recorded in 72 percent of high-risk events but in only 28 percent of moderate-risk events, the same percentage as reported in non-risk-bearing events;
- A delay in making the decision to go around, which was recorded in 39 percent of high-risk events but only 8 percent of medium-risk events, an even lower proportion than for non-risk-bearing events; and,
- A complex situation at the time of the go-around decision, which was recorded in 50 percent of high-risk events but only 8 percent of medium-risk events, about the same as for non-risk-bearing events.

Significant violation of landing minimums, followed by a go-around decision, was a particular precursor of the nine fatal accidents during subsequently attempted go-arounds. Fourteen percent of risk-bearing go-around decisions were made above 1,000 ft; half of these decisions were made because of an unstable approach condition.

Compared with moderate-risk go-arounds, high-risk go-arounds are more likely to:

- Involve pilots with low levels of experience;
- Involve a go-around decision made below decision altitude/minimum descent altitude (DA/MDA);
- Be flown by the PIC as PF;
- Be at risk of LOC;
- Follow a violation of DA/MDA; and,
- Involve surprise that they have become necessary.

High-risk go-arounds are less likely to:

- Follow an unstabilized approach; and,
- Involve a change of PF at initiation of or during the go-around.

Compared with moderate-risk go-arounds, non-risk-bearing go-arounds are more likely to:

- Follow go-around decisions that were foreseen as possibilities, rather than those that occurred unexpectedly; and,
- Be made on ATC instructions.

They are less likely to:

- Take place at night;
- Involve pilots with low levels of experience;
- Have the first officer as PF; and,
- Involve surprise that they have become necessary.

They are just as likely to:

- Be preceded by significant procedural noncompliance; and,
- Involve a change of PF at the initiation of or during the go-around.

6.2 Analysis: Go-Around Execution

The go-around flight operations data analysis was performed with the objective of examining the prevalence of a go-around safety risk during normal, routine operations. More than 1,500 go-around events flown by jet aircraft operated by a range of airlines from around the world were examined. The analysis focused on the point at which the go-around began and the way it was conducted.

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3 Defined in this analysis as one or both of <500 hours on type or <500 hours in command

4 Defined in this analysis as one or both of <2,000 hours multi-crew experience or < 500 hours on type

These go-around events were found in data detailing almost 500,000 flights. The majority of these flights (86 percent) involved single-aisle jets; twin-aisle jets made up the remaining 14 percent.

Data showed that 50 percent of the flight crews disconnected the autopilot above 1,000 ft, 25 percent disconnected the autothrottle above flare altitudes, and 14 percent disconnected the flight director during the approach.

Data showed the overall rate of go-arounds was 0.29 percent, or 1 in 340 approaches. However, it was possible to distinguish two subgroups — a lower go-around rate of 0.20 percent for operators that appeared more likely to subsequently divert following a go-around and a higher rate of 0.35 percent for operators that appeared less likely to do so.

The go-around rate for long-haul (twin-aisle) operations was 0.40 percent — higher than the overall rate.

For single-aisle jets, the autopilot was engaged prior to go-around initiation in 56 percent of the events and remained engaged in 93 percent of these cases. For twin-aisle jets, the autopilot was engaged prior to the go-around initiation in 69 percent of the events and remained engaged in 97 percent of these cases.

Forty percent of all go-arounds were initiated below 500 ft, 15 percent were initiated below the Category I instrument landing system (CAT I ILS) minimum height of 200 ft, and 7 percent were initiated below 50 ft.

Exceedance of the maximum permitted airspeed with flaps extended (V_{FE}) was recorded in 2.4 percent of single-aisle jet go-arounds and 3.4 percent of the twin-aisle jet go-arounds. These V_{FE} exceedances correlated with:

- Failure to reach and/or maintain the appropriate pitch target;
- Extended duration of go-around power settings;
- An elapsed time of more than 10 seconds without retraction of one stage of flaps (this applied in 50 percent of cases); and,
- Unstable approach.

An overall association was identified between the height on the approach at which a go-around was initiated and the pitch attitude at which it was then flown — the earlier the initiation of the go-around, the lower the pitch attitude.

The data showed a widespread prevalence of delayed flap retraction once a go-around had been initiated, whereas in only 3 percent of go-arounds did it take more than 30 seconds to retract the landing gear.

6.3 Findings: Go-Around Execution

A Go-Around Safety Forum — initiated by Flight Safety Foundation, the European Regions Airline Association (ERA) and Eurocontrol — took place June 18, 2013, at Eurocontrol headquarters in Brussels. It was held in support of the Flight Safety Foundation Go-Around Safety Initiative, to assist in early implementation of the actions detailed in the European Action Plan for the Prevention of Runway Excursions (EAPPRE), issued in January 2013. The conference was attended by over 270 participants, including members of the French Bureau d'Enquêtes et d'Analyses (BEA), who were conducting a study of airplane state awareness during go-arounds (ASAGA). (BEA)

The execution findings (Ex Findings) from the Go-Around Safety Forum included the following: (Flight Safety Foundation; ERA; Eurocontrol;)

Ex Finding 1. Go-arounds occur at an average rate of one to three per 1,000 approaches. There is a large variation of go-around rates among different aircraft operators and operational environments.

Ex Finding 2. The go-around is a normal phase of flight, and pilots should be encouraged to conduct one when conditions warrant, as well as when they are instructed to do so. However, since a go-around is the least flown normal flight phase, there are particular safety issues associated with it.

Ex Finding 3. One in 10 go-around reports record a potentially hazardous outcome, including exceeded aircraft performance limits or fuel endurance.

Ex Finding 4. A go-around is a relatively rare maneuver for most commercial pilots. On average, a short-haul pilot may conduct a go-around once or twice a year, and a long-haul pilot may conduct one every two to three years.

Ex Finding 5. Conducting a go-around carries a number of risks including:

- Ineffective initiation of a go-around, which can lead to LOC;
- Failure to maintain control during a go-around, which can lead to LOC, including abnormal contact with the runway, or to CFIT;
- Failure to fly the required track, which can lead to CFIT or MAC;
- Failure to maintain traffic separation, which can lead to MAC; and,
- Generation of wake turbulence, which may create a hazard for another aircraft that can lead to LOC.

Ex Finding 6. The height at which a go-around is initiated during an approach can present different challenges and risks:

- Above the approach procedure minimum altitude;
- At the approach procedure minimum altitude; and,
- Below the approach minimum altitude.

Ex Finding 7. Low relevant experience of one or both pilots is associated with difficulty in flying go-arounds.

Ex Finding 8. Go-arounds that follow a violation of approach minimums are associated with a reduced safety margin.

Ex Finding 9. It is necessary for operators to be aware of the extent to which go-arounds are being flown and the validated reasons for them, as well as the extent to which the go-arounds are flown safely.

Ex Finding 10. A just culture must prevail if problems in go-around safety are to be sufficiently understood and addressed.

Ex Finding 11. Aircraft energy states that are too high or too low make the safe execution of go-arounds less likely, and this situation can be exacerbated by a failure to understand how to manage aircraft pitch attitude.

Ex Finding 12. The safety of a go-around is compromised by a delay in deciding to begin a go-around when the aircraft becomes unstabilized below a mandatory stabilized approach gate (see 10.3.2, Approach Gates, p. 45).

Ex Finding 13. The decisions that precede unsafe go-arounds are often made at points other than pre-determined procedural decision points.

Ex Finding 14. Pilot go-around training needs to be proportional to the rate at which go-arounds are experienced in line operations.

Ex Finding 15. The effectiveness of flight deck monitoring can have a significant effect on the safe execution of go-arounds, but such monitoring often is poor.

Ex Finding 16. Lack of an adequate understanding of automation by pilots can affect go-around safety.

Ex Finding 17. Pilot understanding of how the pitch control system works is not always apparent in their actions during go-arounds.

Ex Finding 18. The potential for a traffic and/or a wake vortex conflict during a go-around is sometimes reduced if pilots are unaware of other traffic in the vicinity.

Ex Finding 19. Most pilots fly the potentially complex transition to a go-around from a circle-to-land approach so infrequently that maintaining competency will require an unrealistic amount of recurrent training in proportion to other requirements.

Ex Finding 20. The extent of controller training in respect to go-around risk management is variable.

Ex Finding 21. Controllers sometimes issue instructions that may prevent pilots from conducting a stabilized approach and may thereby increase the number of go-arounds.

Ex Finding 22. Go-around procedures can be complex at a time of high workload for pilots. The procedures are not always published. Tactical de-confliction of go-arounds can place high demands on controllers. Complexity is increased when there are multiple approach procedures for the same runway, each with its own missed approach point (MAP).

Ex Finding 23. Too much information in one controller radio transmission (e.g., an explanation of the reason when giving an executive instruction) can lead to pilot confusion. Late provision of, or changes to, go-around instructions (including late changes to a published MAP unless these clearly simplify it) increase workload for pilots.

Ex Finding 24. Some pilots are reluctant to decline acceptance of ATC instructions that are not compatible with aircraft performance, especially when issued at times when pilot workload is already high. Issuing unpublished go-around/missed approach tactical instructions at or after the initiation of a go-around can place high demands on pilots. There is no direct link between aircraft operator and ATC go-around training/awareness.

Ex Finding 25. Current pilot go-around procedures may not adequately address all the circumstances in which an ad hoc go-around decision may be made, especially above 1,000 ft AGL or after a decision to continue an approach made at DA/MDA.

Ex Finding 26. Go-around operational challenges are not adequately reflected in current regulatory requirements.

6.4 Strategies for Corrective Action: Go-Around Execution

The Safety Forum discussed in depth the issues related to go-around decision making, execution and training, and the air traffic management aspects of safe go-arounds. Forum participants agreed on a series of conclusions in respect to eight safety improvement strategies. Three of these strategies were execution strategies (Ex Strategies) related to the safe execution of go-arounds:

Ex Strategy 1. Ensure that go-around training and awareness appropriately reflect different go-around execution risk scenarios.

Note: Independent CAST analysis determined similar findings and recommendations, which are outlined in CAST Safety Enhancement (SE) 198.

Ex Strategy 2. Review go-around policy, procedures and documentation to maximize their effectiveness, clarity and understanding.

Ex Strategy 3. Ensure that low relevant experience of one or both crewmembers does not prejudice the effectiveness of monitoring during approach, landing and go-around.

6.5 Recommendations: Go-Around Execution

The following principal recommendations for safe go-around execution (Ex Recommendations) are based on Safety Forum conclusions:

Ex Recommendation 1. Aircraft operators and ATC should improve their mutual understanding of each other's go-around practices/procedures.

Ex Recommendation 2. Industry partners should develop go-around training aids.

Ex Recommendation 3. Effective monitoring depends on ensuring that pilots with low relevant experience are able to contribute to safe go-around decision making and execution.

Ex Recommendation 4. Pilots and their employers should understand that one of the many reasons that violating approach minimums is unacceptable is because evidence indicates that if a go-around then becomes necessary, the chances of a safe transition to the go-around are reduced.

Ex Recommendation 5. Pilots must be able to demonstrate that they are able to safely execute go-arounds that begin from both high energy and low energy states at the point where a go-around decision is indicated.

Ex Recommendation 6. Pilots must be able to exercise tactical judgment, as well as procedural compliance, when deciding to go around below a stabilized approach gate so that safe execution is not hindered by an inappropriate delay in decision making. Validation of this must be achieved through realistic training scenarios.

Ex Recommendation 7. Go-around training for pilots should include a range of operational scenarios, including go-arounds from positions other than DA/MDA and the designated stabilized approach gate. Scenarios should involve realistic simulation of surprise, typical landing weights and full-power go-arounds.

Ex Recommendation 8. Go-around training for both pilots and controllers should incorporate lessons learned from operational events/incidents.

Ex Recommendation 9. Clear guidance should be provided to pilots on how to act in respect to the three stages of monitoring during approach, landing and go-around: noticing, alerting and taking control. Members of augmented crews who are observing should have a clear understanding of the nature of their contribution to effective monitoring.

Ex Recommendation 10. If an aircraft has the capability to fly automatic go-arounds, pilot training should be provided and the operator's automation policy should address the go-around procedure.

Ex Recommendation 11. Pilots must have a clear understanding of how the pitch control system works on the aircraft type that they fly. This should be validated by both theoretical testing and use of suitable full flight simulator exercises involving approach and go-around with full, rather than reduced, power/thrust available and at typical landing weights.

Ex Recommendation 12. A review should be conducted to determine whether pilots can lose situational awareness of potentially conflicting traffic during go-arounds if other pilots are exchanging radio transmissions with ATC in languages other than English.

Ex Recommendation 13. A high priority should be accorded to the provision of RNP approach and missed approach procedures when current procedures involve circle-to-land and when active radar surveillance of the transition to a go-around is not available. Consideration should be given to withdrawing circle-to-land procedures at airports where neither option is available.

Ex Recommendation 14. Air navigation service providers (ANSPs) should review and, if necessary, enhance the provision of go-around risk awareness training for controllers.

Ex Recommendation 15. Ensure that the importance of facilitating a stabilized approach and the correct application of final approach procedures is included in training and in briefings for ATC staff (EAPPRE Recommendation 3.3.1).

Implementation Advice:

- Training should include:
  a. Appropriate speed control instructions;
  b. Timely descent instructions;
  c. The importance of avoiding a late change of runway or change in the type of approach;
  d. The importance of assigning a landing runway with no significant tail wind component;
  e. The need to avoid vectoring too tightly onto final approach and intercepting glide path from above; and,
  f. The importance of providing the crew with correct information about distance to touchdown.

Ex Recommendation 16. The agency responsible for instrument approach procedure design should ensure that straightforward go-around procedures are available and published for each runway. These go-around procedures should be designed in consultation with pilots who are representative of those who will be expected to use them.

Implementation Advice:

a. The principles, which underlie the MAP for each runway, should, as much as possible, be the same.

b. A low (e.g., below 2,000 ft) first stop altitude and an early turn in a missed approach procedure should be avoided;

c. Conditional go-around procedures/missed approach procedures (e.g., “after xxx but not later than yyy”) should be avoided.

d. The (ideally common) missed approach fix should be located close to the airport to ensure that an aircraft in trouble can be landed immediately on any runway with any track-distance chosen by the pilot.

e. Procedural de-confliction of the missed approach path from other traffic and from the risk of exposure to wake turbulence, especially from late go-arounds, should be provided.

f. If both RNP and conventional missed approach procedures are published, then an explicit risk assessment of such availability should be performed.

a. Environmental restrictions — especially noise-abatement restrictions — must not affect the design of missed approach procedures if their imposition would compromise safety standards.

Ex Recommendation 17. On final approach, pilots should be advised of any significant changes in weather and/or runway surface conditions. Contingency arrangements/procedures should exist for use in wind shear conditions.

Implementation Advice:

b. Pilots should receive more relevant and quicker updates of weather-related information about developments such as changes in visibility, wind and runway status (e.g., quantity of water on the runway).

c. Improved information should be provided to crews about tail winds, wind shear and significant wind variation, including reports from preceding aircraft.

d. Runway information should include items such as braking action reports; information about the presence of standing water, debris and wildlife, including birds; reports of technical problems on the ground; and reports of laser interference.

Ex Recommendation 18. Guidance should be developed for controllers regarding the content and timing of go-around instructions.

Implementation Advice:

a. Controllers should consider whether a go-around instruction should be delivered in a separate transmission from one that explains the instruction.

b. Controllers must always use the standard MAP if there is no imperative reason for an adaptation.

c. If a non-standard missed approach procedure is to be followed, controllers should detail it when issuing the approach clearance.

d. Controllers should avoid last-minute changes or instructions except in emergency situations.

e. Once a pilot has declared a go-around or is otherwise known to have begun one, controllers should avoid unnecessary transmissions.

f. Pilot should inform ATC as soon as possible if deviations from the published go-around procedure become necessary.

Ex Recommendation 19. ANSPs should consider the feasibility of establishing a formal interface between pilots and controllers to explore operational issues and reach an understanding.

Implementation Advice:

a. Pilots can be invited to attend controllers’ training sessions, and controllers may be able to arrange to observe pilots’ training sessions.

b. “Open” days can be provided for pilots to observe operations at ATC facilities, and it may be possible to organize familiarization flights for controllers.

c. Pilots and controllers should participate in joint crew resource management training.

d. In establishing such interfaces, be aware that it is most unlikely that the pilots participating in such an initiative will be representative of those using the ATC services involved and any such bias must be explicitly recognized.

Ex Recommendation 20. Aircraft manufacturers should ensure that go-around procedures presented in aircraft pilot training and aircraft operating manuals are applicable to go-arounds that are begun at any stage on final approach, up to and including landings that are rejected after touchdown.

Ex Recommendation 21. Safety regulators should review current mandatory go-around training requirements for both pilots and controllers and should ensure that the conclusions of this report are appropriately addressed.

7 Flight Safety Foundation Future Work

1. Establish a go-around noncompliance industry label such as GANC (go-around noncompliance) or FGA (failure to go around). This is to establish easy recognition, as has been accomplished with other labels, such as LOC or CFIT.
2. Analyze and report, at a global aggregate level, unstable approaches and unstable landings to determine the level of associated risk.
3. Report global go-around compliance performance annually.
4. Develop go-around execution and training guidelines for operators.
5. Establish industry go-around noncompliance audit standards and recommended practices with organizations such as the International Civil Aviation Organization and IATA.
6. In order to minimize the exposure to unnecessary go-arounds while ensuring safety, further analysis is required to determine the risk balance point between an unstable approach and a go-around. The Foundation should ensure industry partners pursue this analysis.
7. Promote the distribution and presentation of this report in industry, and encourage republication in complementing publications and safety initiatives.

8 Project Conclusion

The problem of go-around policy noncompliance is real and is arguably the largest threat to flight safety today. The potential impact of improvement in compliance is significant. No other single decision can have such an impact in the reduction of aviation accidents as the decision to go around.

The first and foremost change required is that the industry must improve its awareness of the problem; to achieve this, a shift in focus and cultural norms is required. It is believed that significant improvement is attainable; however, the cultural shift will be much easier if the industry shifts collectively, as opposed to individual companies making changes on their own. Having said this, several companies are already attacking this issue internally.

The project accomplished the goals set forth in the 2011 document announcing the FSF Go-Around Safety Initiative: “to understand the noncompliance by flight crewmembers, and noncompliance of quality control measures by flight managers,” and to consider the safety risk associated with go-arounds and ensure that the transfer of risk is understood. There are several useable guidelines in the appendix of this report; however, not all envisioned products are completed, and this is noted in the report as future work to be done by Flight Safety Foundation.

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10 Appendices

10.1 Glossary

AGL	Above ground level
ALA	Approach and landing accidents
ALAR	Approach and landing accident reduction
ANSP	Air navigation service providers
ASIAS	Aviation Safety Information Analysis and Sharing program
ATC	Air traffic control
BEA	Bureau d'Enquêtes et d'Analyses
CFIT	Controlled flight into terrain
DA	Decision altitude
DM	Decision making
DMMF	Decision making, management finding
DMPF	Decision making, pilot finding
DMR	Decision making recommendation
DMS	Decision making strategy
EAC	European Advisory Committee
EGPWS	Enhanced Ground Proximity Warning System
Ex	Execution
FDA	Flight data analysis
FDM	Flight data monitoring
FGA	Failure to go around
FOQA	Flight operational quality assurance
FSF	Flight Safety Foundation
GA group	Pilots who elected to go-around vs. continue an approach unstable
GANC	Go-around noncompliance
GASI	Go-around safety issues
GPWS	Ground-proximity warning system
IAC	International Advisory Committee
IATA	International Air Transportation Association
ICAO	International Civil Aviation Organization
IMC	Instrument meteorological conditions
IOSA	IATA Operational Safety Audit
LOC	Loss of control
LOSA	Line operations safety audit
MAC	Midair collision
MAP	Missed approach point
MDA	Minimum decent altitude
PF	Pilot flying
PIC	Pilot-in-command
PM	Pilot monitoring
PNF	Pilot not flying
RA	Resolution advisory
RNP	Required navigation performance
SAH	Stable approach height
SOP	Standard operating procedures
TAWS	Terrain awareness and warning system
TCAS	Traffic-alert and collision avoidance system
UA group	Pilots who continued an approach to landing
VMC	Visual meteorological conditions

10.2 Decision Making Recommendations — Mapping

The following table illustrates the mapping of recommendations to the situational awareness constructs, findings and strategies that they address.

Recommendation	Situational Awareness Constructs Addressed	Findings Addressed	Strategies Addressed
DMR 1	C; 1, 2, 4, 5	DMPF; 1, 2	DMS; 3
DMR 2	C; 1, 2, 3, 4, 5, 6	DMMF; 1, 3, 4, 6, 8, 15	DMS; 2, 3
DMR 3	C; 4, 5, 9	DMMF; 1, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16	DMS; 2
DMR 4	C; 5, 7, 9	DMMF; 7, 15, 16	DMS; 2
DMR 5	C; 2, 3, 4, 5, 7, 9	DMPF; 7, 12, 13, 18, 19	DMS; 1
DMR 6	C; 2, 3, 4, 5, 7, 9	DMPF; 7, 12, 13, 18, 19	DMS; 1,2,3
DMR 7	C; 1, 2, 3, 4, 6, 7, 8,	DMPF; 2, 3, 6, 7, 8, 9, 10, 11, 14, 16	DMS; 1, 3
DMR 8	C; 1, 2, 4, 5	DMPF; 1, 2	DMS; 3
DMR 9	C; 1, 3, 4, 7, 8	DMPF; 1, 3, 14	DMS; 3
DMR 10	C; 1, 2, 3, 4, 6, 7	DMPF; 2	DMS; 3
DMR 11	C; 2, 6, 8	DMMF; 1, 5, 6, 7, 8, 13, 14, 15	DMS; 3
DMR 12	C; 1, 2, 3, 4, 5, 6, 7, 8, 9	DMPF; 14, 15, 17	DMS; 3
DMR 13	C; 3, 4, 7, 8, 9	DMPF; 5, 13, 14	DMS; 1,3
DMR 14	C; 3, 4, 7, 8, 9	DMPF; 5, 13, 14	DMS; 1,3
DMR 15	C; 2, 5, 8, 9	DMMF; 1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15	DMS; 3
DMR 16	C; 4, 6, 7	DMMF; 1, 2, 6, 7, 8, 9, 11, 12, 13, 15	DMS; 2
DMR 17	C; 1, 2, 3, 4, 5, 6, 7, 8, 9	DMPF; 1–19	DMS; 1, 2, 3
DMR 18	C; 1, 2, 3, 4, 5, 6, 8, 9	DMMF; 1, 2, 15	DMS; 2, 3
DMR 19	C; 1, 2, 3, 4, 5, 6, 8, 9	DMMF; 1, 2, 15	DMS; 3
DMR 20	C; 3, 6, 8, 9	DMMF; 1, 9, 11, 12, 13,15	DMS; 2, 3
DMR 21	C; 1, 2, 3, 4, 5, 6, 8, 9	DMMF; 1, 2	DMS; 3

C = construct; DMMF = decision making, management finding; DMPF = decision making, pilot finding; DMR = decision making recommendations; DMS = decision making strategy

10.3 Analysis: New Stabilized Approach and Go-Around Guidelines, 2017 (proposed for industry validation)

New Stabilized Approach and Go-Around Guidelines, 2017 (proposed for industry validation)

An approach is fully stabilized when all of the following criteria are met:

Profile:

- Only small changes in heading/pitch are required to maintain the correct flight path profile.
- Specific types of approaches are stabilized if they fulfill the following:
  - CAT I ILS: within 1-dot deviation of glide path and localizer;
  - RNAV: within ½-scale deflection of vertical and lateral scales and within RNP requirements;
  - LOC/VOR: within 1-dot lateral deviation; and,
  - Visual: within 2.75 and 3.25 degrees of visual approach path indicators, and lined up with the runway centerline no later than 300 ft.

Configuration:

- Aircraft is in the landing configuration (gear and flaps set, speed brakes retracted).

Energy:

- Airspeed is stabilized within V_{REF} +10 kt to V_{REF} (without wind adjustments).
- Thrust is stabilized to maintain the target approach airspeed.
- Sink rate is no greater than 1,000 fpm.

General:

- The stabilized approach gates should be observed, and active communication calls made during each approach.
- Normal bracketing corrections in maintaining stabilized conditions occasionally involve momentary overshoots made necessary by atmospheric conditions; such overshoots are acceptable. Frequent or sustained overshoots are not.
- Unique approach procedures or abnormal conditions requiring a deviation from the above elements require a special briefing.

Approach Gate	Objective[1]	Example of Active Communication[2]
1,000 ft AGL Note: This can vary between 800 and 1,500 ft, depending on aircraft category type	The final landing configuration should be selected.	**PM: "1,000; Configured/Not configured" or "Flaps"** **PF: "Roger"**
500 feet AGL	The aircraft should be fully stable.	**PM: "500; Stabilized/Not stabilized" or "Speed [parameter]"** **PF: "Roger"**
300 feet AGL and below	Initiate a go-around without hesitation if unstable.	**PM: "300; Stabilized/Go around" or "[Condition to go around]"** **PF: "Continue/Go around"**

AGL = above ground level; CAT I = Category I; ILS = instrument landing system; LOC/VOR = localizer/VHF omnidirectional radio; PF = pilot flying; PM = pilot monitoring; RNAV = area navigation; RNP = required navigation performance;
V_{REF} = reference landing speed

Notes:

1. Continuing past the related gate should only occur if meeting the objective of the next gate is achievable; otherwise, go around. Example: If the flight is not configured by 1,000 ft, it could continue if being fully stable by 500 ft is achievable.
2. If the call at the respective gate indicates an undesired state (e.g., "Not configured", or "Flaps"), that call should be repeated at an appropriate interval until the condition is corrected. Example: "Flaps"; "Flaps" repeated every 50 ft.

10.3.1 Stabilized Approach and Go-Around Decision Guidelines (2017) Design Rationale

The following is the rationale behind Flight Safety Foundation's guidelines for conducting stabilized approaches and achieving reliable go-around decision making. Why the change? The current FSF guidelines were established in November 2000 and updated in 2010. Analysis revealed that facets of that guidance are not optimal for effective decision making and that they may encourage go-arounds for approaches involving very low risk. The overall goal is to improve go-around decision making; in revising the stabilized approach guidelines, four objectives must be met:

- The guidelines must make operational sense for both flight crews and management — resulting in greater acceptance of the policy.
- Safety must be ensured during the approach by mitigating against the common types of ALAs —
  - CFIT;
  - Low energy (landing short, hard landing, tail strike); and,
  - Landing runway excursions (overruns, veer-offs).
- It must be ensured that the resulting go-arounds are conducted for approaches of appropriate risk, and not those of very low risk in which a transfer of risk to a go-around maneuver increases overall risk and unnecessarily increases demands on ATC.
- The flight crew's collective situational awareness must be improved through better communication.

Flight crews indicated in the Foundation's project research that current guidelines on when a go-around must be executed are not realistic for most real-world operational environments and approaches. They described what realistic parameters look like from their perspective.

The criteria for which a stable approach is defined can be grouped into three types of parameters: flight path profile (vertical and lateral), configuration (flaps, gear and speed brakes) and energy management (rate of descent, speed and thrust). Add to these the variable environmental conditions (runway length and condition, and weather), and there are four groups of parameters to be considered when designing stable approach criteria.

10.3.2 Approach Gates

We can address all stable approach parameters and ALA safety issues at three procedural gates:

- 1,000-ft AGL configuration gate (variable from 800 ft to 1,500 ft, depending on aircraft type);
- 500-ft AGL stable gate; and,
- 300-ft AGL go-around gate.

The stable approach criteria are the same at each gate for approaches conducted in both IMC and VMC.

10.3.2.1 1,000 Ft AGL Configuration Gate

Previous guidance required that a go-around *must* be conducted if the flight was not fully stable in IMC. With respect to the physics of a go-around, safety is the same in both IMC and VMC; in this context, differentiation of a go-around at 1,000 feet in IMC and at 500 feet in VMC is not required.

The new functional significance of the 1,000-ft mark is that it is the last suitable point along the approach to ensure that final landing configuration is selected and verified by the flight crew. The flap and gear transition, deceleration to final approach speed and thrust stabilization should occur before the aircraft reaches the next gate at 500 ft AGL. It should be emphasized that initial configuration *should* occur before reaching the 1,000-ft gate; this gate is the last point at which final landing configuration should be selected and confirmed.

The 1,000-ft gate is a familiar demarcation to flight crews and is often accompanied by an automatically generated 1,000-ft callout. Note that the 1,000-ft gate may vary for aircraft type and gross weight. The operator should determine the appropriate height of the gate, based on aircraft deceleration characteristics and the manufacturer's recommendations. The following discussion of aircraft energy management during approach is based on the FSF *ALAR Briefing Notes* (Flight Safety Foundation, 2010).

Aircraft Deceleration Characteristics

Although deceleration characteristics largely depend on the aircraft type and gross weight, the following typical values can be considered for quick assessment and management of aircraft deceleration capability.

Deceleration on a three-degree glide path, with landing flaps and gear down: 10 to 20 kt per nm.

Note:

A three-degree glide path is typically equivalent to a descent gradient of 300-ft-per-nm or a 700-fpm vertical speed, for a final approach groundspeed of 140 kt.

Example:

An aircraft with a final approach speed of 140 kt would need to be at a maximum speed of 165 kt at the 1,000-ft gate to be stable at 500 ft. Using the median deceleration rate of 15 kt per nm and descent rate of 700 fpm:

15 kt-per-nm x (500 (ft)/300 (ft/nm) = 1.67) nm = 25 kt.

This gate does not address any particular ALA type but serves to facilitate achieving a fully stabilized approach at the next lower gate (500 ft). Additionally, it is in line with pilot thinking, as seen in experimental data from the project, that aircraft configuration and aircraft energy management are two separate and distinct aspects of a stabilized approach, and the aircraft energy stabilization height can be lower than the aircraft configuration height.

Although a go-around may be *considered* at this gate, not mandating a go-around at this point reduces the overall number of potential go-arounds by allowing low-risk unstable approaches to continue at a safe altitude. (This analysis is discussed in 10.3.2.3.)

Improved collective situational awareness at this gate is achieved through procedural active communication between flight crew.

10.3.2.2 500-Ft AGL Gate

Previous guidance required that a go-around *must* be conducted if the flight was not fully stable in VMC. The revised guidance retains the recommendation that the approach should be fully stable at this gate; however, the mandate to go around has been removed.

Although a go-around may be considered at this gate, not mandating a go-around reduces the overall number of potential go-arounds by allowing low-risk unstable approaches to continue while at a safe altitude. (This analysis is found in 10.3.2.3).

Not mandating a go-around at this gate also aligns with pilot thinking as seen in experimental data from the project findings, indicating a go-around can still be executed safely, even from lower altitudes when conditions are stable or have only minor deviations outside the stable approach definition. As this makes operational sense to those who execute and manage the policy, there is a better likelihood of compliance.

The 500-ft gate is a suitable point in the approach for flight crew to verify all stable approach criteria. It is a familiar demarcation for flight crews and is also often accompanied by an automatically generated 500-ft callout. Being stable at this point in the approach allows for subsequent developing instabilities to be compared against a state of constant energy reduction.

Improved collective situational awareness at this gate is also achieved through procedural active communication between flight crew.

10.3.2.3 300 Ft AGL Go-Around Gate

This 300-ft gate is new. Establishing this gate clearly marks the boundary between higher altitudes where a stable approach is strongly recommended and the point where continuing an unstable descent reduces the margin of safety. It differentiates between approach stability and a go-around decision. These are two distinct flight issues, and from a psychological perspective, they should remain distinct elements in decision making.

It should be understood that the 300-ft AGL value is not intended to be absolute; it can be approximated to take advantage of aircraft automatic callout systems. For example, consider an ILS minimum set for 200 ft AGL. Some manufacturer automatic callout systems provide an alert 80 ft above minimums, so in such cases, 280 ft AGL could be established as the go-around gate value and utilized in the auto callout in the active call procedures.

Descending in an unstable state below the 300-ft gate should be a warning to flight crews that the level of risk is increasing and action is required, whether the aircraft is unstable at this gate or becomes unstable below 300 ft. Analyses indicate that flight crews who continue an unstable descent below 300 ft do not recognize the need for increased concern — or the need for a go-around. The awareness of the increased need for action can be improved by heightening the definition of the aircraft's condition, from being in an *unstable condition* to being in a *condition to go around.* This can prompt the flight crew to make the correct decision — to go around. Martin Smith of The Presage Group explains, "The psychological tipping point (this is the moment of maximum situational awareness) is when the flight crew is primed to pull the trigger on the go-around. The subtle change to a 'condition to go around' is such a primer. In other words, the 'condition to go around' is permission to act, permission to comply." Drawing a comparison to another industry initiative, the pilot not flying (PNF) is now known as the PM — a change that was intended to influence the mindset of the PM and also to alter his behavior in recognition of the importance of monitoring. A similar effect can be realized in identifying an unstable flight condition below 300 ft as a *go-around condition* — a condition that demands a go-around decision.

To further emphasize the point, the 1,000-ft to 300-ft window can be viewed as the *stable approach zone*, with the focus on ensuring that the aircraft is fully stabilized. The area from 300 ft to thrust-reverser–deployment can be viewed as the primary go-around zone, where the focus shifts from stabilizing the aircraft to going around. Using a rejected takeoff below V_1 (the maximum speed in the takeoff at which the pilot must take the first action to stop the airplane within the accelerate-stop distance) as an analogy, a rejected takeoff below 100 kt is considered to occur in a different regime (low speed) compared with a rejected takeoff above 100 kt, a high-speed regime. Here, through training and guidance, there is a shift in psychology for pilots operating in the low-speed vs. high-speed regime. A similar shift can be realized through the approach to landing.

Lowering the go-around execution altitude reduces the overall number of potential go-arounds by allowing low-risk unstable approaches to continue while at higher, safer, altitudes. It makes the stable approach and go-around policies more in line with flight crews' psychological beliefs and more manageable by management, prevents risk transfer from low-risk unstable approaches to potentially higher-risk go-arounds, and limits unnecessary demands on the air traffic system.

If not fully stable at or below this 300-ft gate, the decision to go around should be made without hesitation. A go-around below 300 ft is not necessarily unsafe; this determination depends on the degree and type of approach instability, and aircraft type and performance characteristics. This gate is essentially the beginning of the primary go-around zone from 300 ft to thrust reverser deployment.

At this gate, the low-energy–type ALA is addressed.

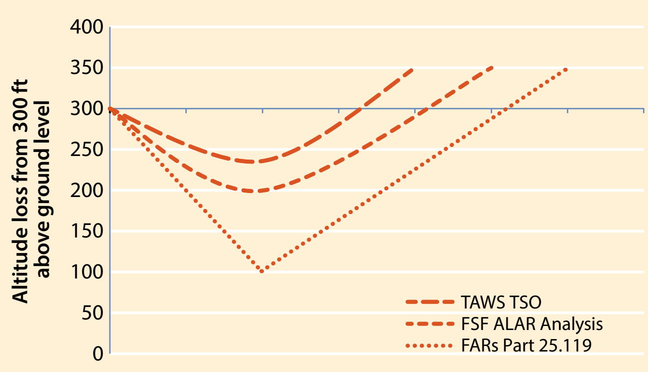
The most common types of low energy ALAs are landing short, hard landing and tail strike. If we analyze the most extreme case of low energy, it is one where thrust is at flight idle, speed is V_{REF}, and the descent rate is 1,500 fpm — double a normal rate of descent.

U.S. Federal Aviation Regulations (FARs) Part 25.119 says, "In the landing configuration, the steady gradient climb may not be less than 3.2 percent, with the engines at the power or thrust that is available eight seconds after initialization of movement of the power or thrust controls from the minimum flight idle to go-around power setting" (FAA), and, "The design and construction of the engine must enable an increase … from the fixed minimum flight idle power from not more than 15 percent of rated takeoff power or thrust available to 95 percent in not less than five seconds" (FAA). The most limiting of these two regulations is the eight-second requirement. In our extreme

Figure 1

Go-Around Altitude Loss Analysis

Unstable condition: Speed V_{REF}, Thrust Idle, Vertical Rate 1,500 fpm



ALAR = FSF Approach and Landing Accident Reduction; FARs = U.S. Federal Aviation Regulations; TAWS = terrain awareness and warning system; TSO = technical standard order; V_{REF} = reference landing speed

Source: Flight Safety Foundation

low-energy case of descending at 1,500 fpm, using a linear analysis without taking into consideration a lessening of the rate of descent as engines spool, and achieving a 3.2 climb gradient, the flight will descend 200 ft (FARs 25.119, Figure 1):

$$1500 \text{ (fpm)}/60 \text{ (sec per min)} \times 8 \text{ (sec)} = 200 \text{ ft}$$

Another useful analysis comes from Flight Safety Foundation's *ALAR Tool Kit*, which says that an aircraft being flown on a go-around while on a 3-degree approach path, with thrust at flight idle, descending at 700 fpm and with V_{REF} at minus 5 kt, will experience an altitude loss of approximately 40 ft (Flight Safety Foundation, 2010). If we more than double the rate of descent to 1,500 fpm, in this analysis, the aircraft would experience an altitude loss of approximately 100 feet (FSF *ALAR Tool Kit*, Figure 1).

It is also interesting to look at design specifications for TAWS such as EGPWS. The technical standard order (TSO) for such systems requires that, for the final approach segment descent, a warning be given in time to allow for a 100-ft obstacle clearance altitude after recovery that includes a one-second pilot response time and 0.25 g (0.25 standard gravitational acceleration) pull-up (Department of Transportation, FAA, 2012).

The TSO further describes the altitude loss of an aircraft descending at 1,500 fpm, with a response time of one second and 0.25 g pull-up as being 64 ft, and says the required warning should be given no later than 164 ft above the obstacle (TAWS TSO, Figure 1).

In comparison with these analyses, a gate of 300 ft AGL to execute a go-around provides adequate altitude margin for even the most extreme low-energy unstable approach. The margin in this case results in a 50 percent increase over the linear eight-second Part 25.119 determination, a 200 percent increase over the FSF ALAR determination and a 370 percent increase over the TAWS determination.

Although the number of approach and landing accidents is greater than the number of go-around accidents, the go-around phase of flight has more fatalities per accident. By ensuring a safe altitude of 300 ft to conduct a go-around in the extreme unstable low-energy case, and by allowing low-risk unstable approaches to continue between 1,000 ft and 300 ft, the potential number of go-arounds would be reduced, lowering the exposure to go-arounds risks.

10.3.2.4 Comparisons of Revised Gates to Industry Monitoring and Alerting Systems, and FAA Runway Overrun Prevention References

The project identified significant decision-making benefits in reducing the subjectivity of the decision-making analysis by flight crew. The most impactful way to minimize subjectivity is to employ automated systems similar in concept to EGPWS and TCAS to help flight crews make timely and consistent decisions. The industry has developed a few systems — in the form of stable approach and landing monitoring and alerting systems — for approach and landing energy management.

The Airbus Runway Overrun Protection System (ROPS) has a number of alerting and monitoring functions, but those that are pertinent to this analysis are the visual alert that begins at 400 ft AGL and the aural alert at 200 ft AGL. ROPS does a present-time evaluation of aircraft real energy and the runway distance available for landing, and provides a visual "Runway Too Short" alert at 400 ft and an aural alert at 200 ft (Armaund Jacob, 2009) (Airbus, 2013). Because of the lower altitudes at which these alerts occur, and considering the severity of the condition — that is, not enough runway to stop the aircraft — a go-around really is the only option, except in the most dire emergencies. When comparing this condition to the conditions being applied to the proposed "New Stabilized Approach and Go-Around Guidelines" (p. 44), the FSF guidelines are quite conservative.

Honeywell SmartLanding System also has many alerting and monitoring functions, including aural alerts beginning at 450 ft AGL and ending at 300 ft AGL with an "Unstable, Unstable" alert. The criteria used by the system to make the alert are variable but based on monitoring excessive approach angle, excessive speed and flap settings (Honeywell International, 2009). Again, the altitudes where these alerts are given are similar to those recommended in the "New Stabilized Approach and Go-Around Guidelines."

10.3.3 Achieving Collective Situational Awareness Through Active Communication

This project found that situational awareness is lacking among most flight crews who continue an unstable descent and land unstable. Communication is vital in achieving high-functioning situational awareness. Two key types of communication are recommended for improvements — approach and landing *briefings,* and *active communication* SOPs throughout the approach.

10.3.3.1 Pre-Descent Approach and Landing Briefings, and Pre-Approach Briefings

Most airlines already have procedures for briefings, which address the most important aspects of the approach and landing; detailed guidance is provided in FSF *ALAR Briefing Note* 1.6. (Flight Safety Foundation ALAR Task Force, 1998–1999). The following guidance is not intended to replace those briefings but is an addition to current standard briefing guidance:

- Improve overall ALA awareness (statistics); and,
- Improve awareness of specific approach and landing risks.

As demonstrated in the project data, simply knowing a few overall statistics can raise situational awareness significantly. When company statistics are available, they should be referenced; however, in their absence, the following industry statistics can be used:

- ALAs make up approximately 65 percent of all accidents;
- Approximately 3 percent of unstable approaches result in a go-around; and,
- More than 50 percent of runway excursions follow a stable approach that becomes unstable after threshold crossing.

Additionally, reviewing the effects of runway contamination and tail winds on runway excursions is relevant because they contribute to a significant number of runway excursions. The Flight Safety Foundation–led Runway Safety Initiative found that about 53 percent of runway landing excursions are veer-offs; of that percentage, 66 percent follow stable approaches. Of all veer-offs, 40 percent were associated with wind, and 39 percent, with runway contamination. The remaining 47 percent of runway landing excursions are overruns, and of that group, 63 percent follow unstable approaches (Flight Safety Foundation, 2010).

This project found that awareness of instabilities is critically important in the landing phase as well as in the approach phase. Some simple rules of thumb regarding the effect of poor landing technique on landing distance can significantly improve situational awareness.

For example, pilots should plan for landing distances to increase by (FAA, 2007):

- 250 ft per second of floating;
- 300 ft per 10 kt excess speed from V_{REF} on a dry runway;
- 500 ft per 10 kt excess speed from V_{REF} on a wet runway; and,
- 200 ft per 10 ft excess above 50 ft over runway threshold. This also applies when the vertical guidance for the approach, by design, places the aircraft higher than 50 ft AGL when crossing the threshold. Landing distances are based on a 50-ft threshold crossing.

Briefings including these statistics and rules of thumb should occur at intervals that will ensure that flight crews have an in-depth awareness of the information, for example bi-monthly.

Briefings also should discuss any allowances for flight crews to adjust company policies (see discussion in 10.4, "Revised Safe Landing Guidelines, 2017," p. 51) as permitted by guided procedures in the policies themselves — for example, allowing a crew to conduct a touchdown beyond the normal

Pre-Descent Approach and Landing, and Pre-Approach, Briefing Guidance, 2017

A pre-descent briefing should include, in addition to existing approach briefing components, an emphasis on approach and landing threats. When available, company statistics should be used.

Periodically (e.g. bi-monthly) the briefing should include approach and landing accident (ALA) statistics;

- Overall statistics:
  - ALAs make up approximately 65 percent of all accidents;
  - Approximately 50 percent of runway excursions develop from approaches that become unstable after threshold crossing; and,
  - Approximately 3 percent of unstable approaches or unstable landings result in a go-around.
- Runway excursion environmental contributors:
  - 53 percent of landing excursions are veer-offs, with wind a factor in 40 percent and runway contamination a factor in 39 percent. About 66 percent of veer-offs follow stable approaches; and,
  - 47 percent of landing excursions are overruns; of these, 63 percent follow unstable approaches.
- Landing distance increase rules of thumb:
  - 250 ft per second of floating;
  - 300 ft per 10 kt excess speed from V_{REF} (reference landing speed) on a dry runway;
  - 500 ft per 10 kt excess speed from V_{REF} on a wet runway; and,
  - 200 ft per 10 ft excess above 50 ft over runway threshold.

For each approach ,the briefing should include:

- Environmental ALA threats — contamination, crosswinds, tail winds; go-around readiness. In addition to a normal go-around briefing, heightened readiness should be discussed in the event of poor environmental conditions; and,
- Any adjustments to approach and landing policy requirements, as permitted by written policy guidance (e.g., landing beyond the normal touchdown zone if performance permits).

Pre-approach briefing:

- At an appropriate low-workload period, just prior to commencing the approach, crews should recap current environmental threats, go-around readiness and any adjustments to go-around policy procedures.

Source: Flight Safety Foundation

touchdown zone as long as adequate landing performance and distance references exist.

Finally, as pre-descent briefings often occur 30 minutes or more before an approach, the project findings and recommendations suggest that a short update, or refreshment of the current threats and go-around readiness, be briefed just prior to the approach during a low-workload period in the lower descent. This can refresh and "top up" flight crews' situational awareness.

10.3.4 Pre-Descent Approach and Landing, and Pre-Approach, Briefing Guidance

10.3.4.1 Active Communication Throughout the Approach

This project determined that communication is one of the key attributes of effective collaborative decision making by flight crews. By a factor of approximately four, flight crews who comply with their company's go-around policy had communicated about approach instabilities, and for most crews who continued an unstable approach and landing, *no one* made the actual decision to continue; that is, there was no communication about the decision to continue, it just happened. The difficulty with passive/conditional calls (those which are made only if a problem condition exists — e.g., "airspeed") is that in their absence, it is undetermined if the condition exists. The call could be absent for several reasons, as explained in the report findings. Active calls, however, force flight crews to speak, discuss or express a condition — either positive or negative — on every approach.

It is also important not to overload the flight crew with standard communication and to ensure that they have time to listen to ATC and perform other tasks; therefore, active calls must be short and direct.

Active calls are usually initiated by the PM and responded to by the PF. The PM's call on the approach normally indicates a condition, and the response by the PF may either be an acknowledgment or a directional response.

It is recommended that there be an active call at each approach gate.

If the active call indicates an undesired aircraft state, the call should continue to be made periodically throughout the approach at intervals such as each 50 ft or 100 ft, until the desired state is achieved or a go-around is conducted. This serves the same purpose as a warning from EGPWS or TCAS.

Active, repetitive calls in the 1,000- to 300-ft zone also prepare the PF for an eventual conclusion if the offending condition is not corrected; that is, a go-around. Repetitive warning calls prime the PF's anticipatory, compensatory, hierarchical and relational awarenesses, as compared with common current procedures in which a sudden, single "Unstable Go Around" call is made at 1,000 or 500 ft, which has a lesser effect in primarily the hierarchical awareness.

The implementation of active calls should not imply that passive/conditional and communicative calls such as "glideslope" or "speed" be omitted. Passive calls remain an important component of situational awareness and should be used in combination/coordination with active calls, as required.

The following are examples of active calls at approach gates during an approach:

Gate	PM Active Call	PF Response
1,000 ft AGL	"1,000; Configured/Not configured" or "Flaps"	"Roger"
500 ft AGL	"500; Stabilized/Not stabilized" or "Speed [parameter]"	"Roger"
300 ft AGL	"300; Stabilized/Go around" or "[Condition to go around]"	"Continue/Go around"

AGL = above ground level; PF = pilot flying; PM = pilot monitoring

Source: Flight Safety Foundation

If an airline has a stable approach and monitoring system installed, such as ROPS or SmartLanding, the need for a complete series of active calls throughout the approach and landing is largely removed. These systems apply passive/conditional calls; however, the nature of the automation provides a form of reliability that passive calls from flight crews do not.

10.4 Analysis: Revised Safe Landing Guidelines, 2017 (proposed for industry validation)

Safe Landing Guidelines, 2017 (proposed for industry validation)

1. Fly a stabilized approach.
2. Height at threshold crossing is 50 ft.
3. Speed at threshold crossing is not more than V_{REF} + 10 kt indicated airspeed and not less than V_{REF}.
4. Tail wind is no more than 10 kt for a non-contaminated runway, no more than 0 kt for a contaminated runway.
5. Touch down just beyond the touchdown aim point following a normal flare, and not beyond the touch down zone (TDZ). If not touched down within the TDZ (or revised touchdown point limit) — go around.[1]
6. Touch down on the runway centerline with the main landing gear on both sides of (straddling) the runway centerline. If all main landing gear are on one side of the centerline — go around.
7. After touchdown, promptly transition to the desired deceleration configuration:
    - Brakes;
    - Spoilers/speed brakes; and,
    - Thrust reversers or equivalent (e.g., lift dump).
    - Note: Once thrust reversers have been activated, a go-around is no longer an option.
8. Speed is less than 80 kt with 2,000 ft of runway remaining.

Landing Gate or Condition	Objective	Example "Active" Communication
TDZ End (or modified touchdown point limit as per company SOP)	**The aircraft must be touched down before the end of the TDZ** (or modified landing point limit)	**PM: "End of Zone"**
Exceeded centerline drift limit	**Alert Pilot Flying**	**PM: "Drift Limit"** Note: This is a passive call and made only if condition exists

SOP = standard operating procedure; V_{REF} = reference landing speed

Note:

1. Touchdown aim point is defined by the U.S. Federal Aviation Administration as 1,000 ft from the runway threshold. The International Civil Aviation Organization defines touchdown aim point in reference to the available landing area, as follows:

Available landing area	< 800 m	800–1,200 m	1,200–2,400 m	> 2,400 m
Touchdown aim point	150 m	250 m	300 m	400 m

Touchdown aim point markings are 150-ft-long white rectangular stripes, one on each side of the runway centerline, that begin at the distances indicated above. The width of the aim-point markings varies with the width of the runway.

Source: Flight Safety Foundation

10.4.1 FSF Safe Landing Guidelines (2017) Design Rationale

The following is the rationale behind the revised Flight Safety Foundation guidelines for safe landing and achieving reliable go-around decision making during the landing phase. As with the stable approach and go-around decision guidelines, there were several objectives, namely that the guidelines must:

- Make operational sense for both flight crews and management to improve agreement with the policy;
- Ensure safety during landing by mitigating the common types of ALAs: landing runway excursions (overruns and veer-offs);
- Ensure the resultant go-arounds are in situations of appropriate risk, and not those of very low risk in which a transfer of risk to a go-around maneuver increases overall risk, and unnecessarily increases demands on ATC; and,
- Improve the flight crew's collective situational awareness.

The guidelines established here do not replace manufacturer limitations and procedural guidance, or state regulations and guidance.

Excursions that occur following an unstable approach are mitigated largely in the approach phase; however, they can still be prevented in the landing phase. Additionally, large numbers of excursions occur following a stable approach that becomes unstable only after the aircraft passes the runway threshold. Guidelines in this section are targeted at these types of excursions.

Landing excursions are of two types: overruns, in which aircraft run off the end of the runway surface and veer-offs, in which aircraft exit the side of the runway surface. To address these types of ALAs, we will enhance landing guidelines in four areas:

- Longitudinal limit awareness (runway touchdown zone and distance);
- Lateral limit awareness (runway centerline);
- Environmental variability and adjustments to established policies; and,
- Situational awareness and communication.

Project findings include that collective situational awareness is low during the landing phase. And although most operators have policies defining where the touchdown should occur, very few have guidance or SOPs on how to determine where the touchdown occurs, or how and when to determine if a go-around should be executed. For example, most operators specify that the aircraft should touch down in the touchdown zone (TDZ), on the centerline; however, they do not train or specify how to determine if the aircraft has passed the TDZ, who should make the determination, or how much of a deviation from the runway centerline is permissible before a go-around should be conducted. Most pilots say either a gut feeling or experience helps them judge when an aircraft has passed the acceptable limit, even though they readily state that their experience does not include go-arounds from the landing phase.

The impact of improving collective situational awareness in the landing phase can be significant.

10.4.2 Longitudinal Limit Awareness (Runway TDZ and Distance)

Touchdown zones vary in length with one determining factor being total runway length. Runways of 7,990 ft and longer have touchdown zones 3,000 ft long (FAA), and runways of 2,400 m and longer have touchdown zones 900 m long (ICAO). Relative positioning markings are present within the TDZ and are clearly identifiable on a non-contaminated runway. The aiming point is the widest marking located at the 1,000-ft distance from the threshold (FAA), and 400-m distance from the threshold (ICAO), with the end of the TDZ being identified by the last marking at 3,000 ft (FAA) and 900 m (ICAO).

Approach alerting and monitoring systems such as SmartLanding provide aural alerts when an aircraft has passed a company-defined touchdown area. When an aircraft passes this area without touching down, an aural alert such as "Deep Landing, Deep Landing" is given (Honeywell International, 2009). SOPs then dictate a go-around. This objective warning immediately enhances crew awareness and leads to better decision making. In the absence of such a system, the PM, through SOPs, can be directed to monitor the passing of TDZ markings and make an active call such as "TL" [touchdown limit], "deep landing" or "end of zone" after passing the last marking indicating the passage of the TDZ.

In cases in which the runway is contaminated and markings are not visible, a couple of options exist. If available, runway-remaining markers can be used, or, using the landing distance "Rules of Thumb,"' pilots can calculate that, for an aircraft traveling 250 ft per second, the normal touchdown area of 1,000 to 2,000 ft will occur in four to eight seconds — 250 fps x 4–8 seconds = 1,000 to 2,000 ft.

Calculations also will show that the end of the 3,000-ft-long TDZ will pass in approximately 12 seconds — 3,000 ft/250 fps = 12 seconds.

10.4.3 Lateral Limit Awareness (Runway Centerline)

Most operators specify that the touchdown shall occur on the runway centerline, but do not say how this will happen or who will determine when the aircraft is drifting. As important as it is to have situational awareness regarding a longitudinal limit, it is equally important to understand lateral limits.

Manufacturers often provide cockpit visual cues and techniques for determining where the main landing gear is in relation to the aircraft centerline.

As an example, Boeing says that, for the 787, the view through "the lower outboard corner of the pilot's forward window to the ground is a good visual reference for the outboard side of the main landing gear wheels on the same side. The lower inboard corner of the pilot's forward window is also a good reference for the opposite side main gear wheels" (The Boeing Company, 2013).

In the absence of other lateral limits, maintaining the most outboard main landing gears on either side of the centerline (straddling) is a reasonable limit. Using visual cues, as in the example above, can help determine the positioning of the main landing gear. This is considered a rough operational guideline with its own limitations; however, there are no known alternatives other than relying on "gut sense." The monitoring of this positioning can be performed by the PM during the landing, and if he or she sees that the position of the aircraft is incorrect, he can make an appropriate call — "Drift Limit." In that case, SOPs would dictate a go-around.

10.4.4 Environmental Variability and Adjustments to Established Policies

Environmental variability can have a significant effect on landing performance and desired touchdown points. Operators should consider giving flight crews the tools and guidelines to determine when it makes sense to modify or adjust landing and go-around policies for safety, and possibly operational efficiency. It can be difficult for some operators to consider allowing a crew to land beyond the TDZ; however, landing performance, combined with sound guidance and policies for operating outside normal definitions, makes sense when safe operations are assured. “Beyond over-proceduralization, we also have the problem of rules with no room to apply judgment,” Kern said in a 2009 book. “Many of these policies begin with good intent. But inside the good intent, we create systems that defy logic and poison the well of fairness, which often results in an unintended consequence — loss of faith in the system of rules” (Kern, 2009).

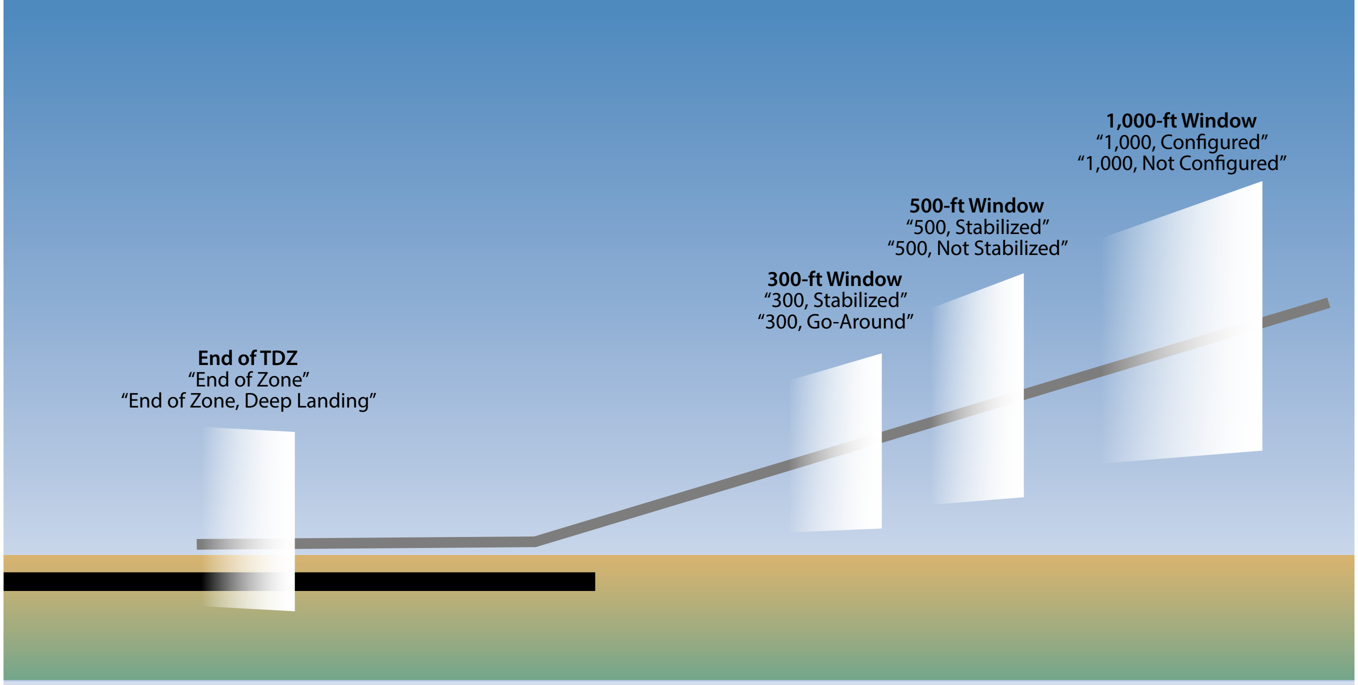
Problems can develop when environmental conditions are such that operating outside established policies makes sense, but there are no guiding principles on how to accomplish this. For example, an aircraft landing on a 12,000-ft (3.7-km) runway requires a 3,500-ft (1-km) landing distance. Although the company policy states that a go-around should be initiated if touchdown does not occur inside the TDZ, is it the best course of action as opposed to an option of extending the touchdown point to 4,000 ft (1.2 km), for example? Certainly, the answer is yes, if the 4,000-ft mark is not definable. However, if the flight crew can identify this point and if they have briefed the revision to the policy, is it still the best course of action to go around? In this case, the transfer of risk to a go-around is questionable. A revised touchdown point can be determined by citing a known distance point along the runway (e.g., taxiway marking, runway distance marker or time period — one second approximates 250 ft (76 m) in distance).

In another case in which weather and runway conditions demand that touchdown occur before the end of the TDZ, guidance should give crews the methods and means to identify the shorter touchdown limit. For example, if the crew wants to be touching down within 2,000 ft (610 m) of the runway threshold, they need references to determine where this will occur, using TDZ markings or time lapse (in seconds) from the time the aircraft crosses the threshold.

In any case, written policies and guidance must be in place to give the flight crew permission, procedures and techniques to modify a landing point limit. This should be briefed and agreed upon by all crew.

Figure 2

Approach and Landing Gates and Active Calls*



TDZ = touchdown zone

* Calls can be substituted with auto callouts such as “1,000,” “500,” “Approaching Minimums,” “100 Above.”

Source: Flight Safety Foundation

10.4.5 Situational Awareness and Communication

Figure 2 (p. 53) shows examples of new active communication calls recommended in the landing phase of flight. In the case of exceeding a centerline touchdown limit, it is difficult to define a point in the TDZ where a positive centerline active call can be made. Although not ideal, in this case, the use of a passive/conditional call may be more operational; that is, the call is made only when the drift limit is reached. Note that stable approach and landing monitoring and alerting systems accomplish the objectives of some active calls; therefore, flight crew calls would not be required.

10.5 FSF Recommended Elements of a Stabilized Approach (2000) [for reference]

Recommended Elements of a Stabilized Approach

All flights must be stabilized by 1,000 ft above airport elevation in instrument meteorological conditions (IMC) and by 500 ft above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 kt indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 fpm; if an approach requires a sink rate greater than 1,000 fpm, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 ft above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 ft above airport elevation in IMC or below 500 ft above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Toolkit Update (Release 5.0 2010)