DEDICATED TO HELPING BUSINESS ACHIEVE ITS HIGHEST GOALS.

NBAA

REDUCING RUNWAY EXCURSIONS IN BUSINESS AVIATION

A high-level guide on mitigating the risks

TABLE OF CONTENTS

REDUCING RUNWAY EXCURSIONS IN BUSINESS AVIATION

INTRODUCTION

A runway excursion is defined by the FAA as an aircraft departing the end (overrun) or side (veer-off) of the runway surface. This can and does occur during takeoff, but the vast majority of runway excursions occur during landing.

Runway excursions continue to be the leading cause of accidents in business aviation. In its 2022 Safety Report, the Flight Safety Foundation stated, "Runway excursions were, by far, the most common accident type in corporate jet operations in 2022 and throughout the period under review." According to their statistics, in a review of accident types between 2017 and 2022, there were 79 runway excursions worldwide, which accounted for more than the next two accident types combined and nearly 41% of all accidents during that period. Of those 79 accidents, six were fatal, resulting in 18 total deaths.

In addition to the avoidable loss of life, the inevitable litigation that follows such tragedies and the related hull losses have also contributed to a reduction in the number of insurance underwriters in the aviation sector over the past decade, as many have left after consecutive years of financial losses. This market tightening has induced significant insurance premium increases, with most operators seeing a double-digit rise each year from 2018 onward. Since the insurance market is based on the contributions of all insured parties pooling resources, drastic and repeat reductions in that pool must be replenished by the pool's participants (the insured parties), thus making all parties pay for the mistakes of a few.

As a sector of professional aviation, business aviation operators can and must make a concerted effort to reverse this trend of runway excursions. This guide is intended to be an easily accessible resource for flight departments of any size to begin or continue the discussion around mitigating the risks of runway excursions. More in-depth resources are also cited throughout this guide for those who choose to seek a deeper understanding of the causal factors and their associated risk mitigation tactics.

This guide is intended as a high-level overview of the numerous causal factors of runway excursions on both takeoff and landing, along with strategies to help mitigate those risks. To that end, this should not be construed as an exhaustive exploration of runway excursions, but rather an easily digestible reference for beginning or continuing the conversation within a business aviation operation on how to minimize the chance of having a runway excursion.

For those who wish to dive into the data referenced herein, links to the source documents, which have been put together by experts in this particular aspect of aviation, are provided herein.

Regardless of how in-depth the reader chooses to go on this subject matter, it is important to note that the causes of runway excursions cannot be boiled down to only one or two factors. Furthermore, despite the wealth of knowledge the industry has gained on runway excursions over the past few decades, there remains precious little exploration into the psychological factors that contribute to this ongoing trend. However, since runway excursions almost always result from decision-making by the crew, the psychology behind those decisions is important to understand. The first section of this guide is an attempt to highlight some commonly accepted attitudes and mindsets that tend to underpin a decision to proceed with a takeoff or landing when an objective third party or "Monday morning quarterback" would question such a decision.

Beyond the psychological factors, it is equally important for flight crews and operators to understand the physical aspects that lead to runway excursions. This can include performance-, weather-, surface-, aircraft-, and human-related factors that, when poorly understood or unappreciated, can and often do contribute to a runway excursion, especially when multiple factors are present. This guide breaks these factors down for takeoff and landing since the intermingling of these factors can have different effects on each phase of flight.

Once psychological and physical factors are better understood, it's important for an operator to incorporate what they have learned into their ongoing training program. It is equally important to take advantage of the knowledge already gained by the industry and developed into enhanced training opportunities through recognized Part 142 training providers.

Finally, as with any other aspect of aviation, an active safety management system (SMS) can pay huge dividends in recognizing hazards and risks to an operation and developing mitigation strategies for those risks. This can be further complemented by the implementation of a flight data monitoring program so that operators can have a better understanding of how the aircraft are actually being operated on every flight in order to recognize trends and address them before an incident or accident occurs.

SECTION 1

Psychological Factors

1.1. PROFESSIONALISM

There are many ways to define professionalism. According to NBAA's professionalism page, "Professionalism in aviation is the pursuit of excellence through discipline, ethical behavior, and continuous improvement." It goes on to cite nine components that contribute to professional behavior in the form of the acronym, PREFLIGHT:

DEDICATED TO HELPING BUSINESS ACHIEVE ITS HIGHEST GOALS NBAA

Professionalism is more than just a paycheck.

P	PREPARED	Preparation happens before you arrive at the airport.
R	RESPECTFUL	Show respect for anyone with whom you interact.
E	ETHICAL	Be fair and honest. Abide by the regulations.
F	FOLLOWS POLICIES AND PROCEDURES	Having and following SOPs drastically reduces the odds of an incident or accident.
L	LEADS BY EXAMPLE	Be the person you want others to emulate.
I	INTEGRITY	Do the right thing, even when nobody is looking.
G	GENUINE	Be authentic in your quest for continuous improvement.
H	HUMBLE	Have the humility to realize you're capable of making mistakes...
T	TRANSPARENT	...and then own those mistakes as a learning opportunity for yourself and others.

Dr. Tony Kern's Integrated Model of Professionalism states that professionals exhibit leadership qualities, outstanding achievements and significant contributions in the categories of vocational excellence, professional ethics, continuous improvement, professional engagement, professional image and selflessness.

Regardless of how it's defined, consistent professional behavior is a precursor to mitigating risks in all aspects of aviation. Conversely, a lack of professionalism may not necessarily lead to an accident such as a runway excursion, but it drastically increases the likelihood of such an occurrence.

One of the most notable runway excursions was the crash of a Gulfstream G-IV during takeoff from Hanscom Field (BED) in Massachusetts in 2014. The NTSB report noted that the airplane failed to become airborne because the flight crew had not released the gust lock system and could not pitch the airplane up after passing V1. An attempt to abort the takeoff occurred once the crew realized the problem, but the airplane overran the end of the runway, killing all seven aboard in a post-crash fire. The NTSB also noted that this crew engaged in a "…pattern of noncompliance with an important step in the manufacturer's After Starting Engines checklist – the flight control check – which appears to have been intentional." This flight crew displayed a lack of professionalism by habitually disregarding policies and procedures created by the manufacturer, which ultimately led to the runway excursion that took their lives and that of the passengers who had placed their trust in them.

The obvious question to ask is why a highly experienced, well-trained flight crew, who flew this airplane for a living, engaged in what seems to be, in retrospect, flagrantly hazardous behavior? Many possibilities abound:

- **Procedural drift** – If a person routinely performs a checklist item that never reveals a problem, that item may be discarded as an ineffective protection not worthy of continued effort.
- **Expectation bias** – When an activity is conducted in a certain manner numerous times with a successful outcome, that outcome becomes expected and the possibility of a negative outcome is no longer considered.
- **Complacency** – When an activity such as a checklist becomes routine, the steps to complete that activity are given less consideration or attention.

Furthermore, while this crew displayed a pattern of procedural noncompliance, it may be tempting to conclude that their unprofessional behavior necessarily led to the circumstances that caused this crash. However, professionalism is not binary, but rather fluid. Even the most dedicated individuals have, on occasion, succumbed to the very human temptation to cut corners, disregard warning signs, or rationalize what would otherwise be considered poor decision-making under the right set of circumstances – some of which will be discussed in subsequent sections. It should also be noted that procedural noncompliance does not have to be habitual to be deadly. Numerous examples of similar runway excursions on takeoff have occurred because a flight crew simply got distracted by non-routine circumstances and failed to conduct a checklist, or to conduct it thoroughly, and the airplane was not properly configured for takeoff.

Professionalism is a choice. One that must be made all day, every day. While a dedication to a vocation does not make us impervious to mistakes, it is a primary means of mitigating risk by compelling a high level of intentionality around every aspect of how we operate aircraft in a very dynamic aviation environment.

1.2. OTHER PSYCHOLOGICAL FACTORS

There are numerous other psychological factors that can unduly influence our decision-making while operating aircraft. While all of these factors could influence a person in any industry, when placed in a safety-sensitive and often time-critical environment like aviation, the consequences of not being aware of these influences – and how to combat them – can have detrimental results.

1.2.1 Management pilots

Flying with and flying as a management pilot in business aviation both have unique challenges that must be recognized.

The primary challenge of flying as a line pilot assigned to a crew with a management pilot can best be described as blurring the lines of authority. This is especially true when the management pilot is acting as SIC. The PIC may feel added pressure to follow the suggestions of "the boss," even when contrary to their own instincts. According to CVR data from the 2019 runway excursion and subsequent fire of a Citation Latitude at 0A9, the PIC and pilot flying appeared to recognize the visual approach did not meet stabilized approach criteria and, at 15:37:32 in the transcript, queried the SIC and chief pilot if a go-around was warranted, to which the chief pilot simply replied, "No." Would the PIC have made a different decision if he was not flying with a management pilot?

Similarly, management pilots must be aware that their input into the crew's overall decision-making will be weighed more heavily than others and tailor their comments accordingly. However, this knowledge can cause the opposite problem. An SMS report from a Part 91 operator indicated that, while serving as SIC and pilot monitoring on a visual approach to the crew's home airport, a flight department manager watched as the formerly stabilized approach became unstable below 200' AGL as the pilot flying drifted above the PAPI glideslope and ultimately landed long. The report indicated that the manager was reluctant to speak up because he knew that his words carried extra authority and could be misconstrued as an outsized criticism of the pilot's approach. Fortunately, the landing ended uneventfully, and the report led to an honest discussion with the entire pilot group about the challenges and responsibilities of flying with and as a management pilot.

1.2.2 Unfounded belief in our own abilities

According to the Flight Safety Foundation's Go-Around Decision-Making and Execution Project from 2017, "Interestingly, and sadly, the collective industry performance of complying with go-around policies is extremely poor – approximately 3% of unstable approaches result in go-around policy compliance." As an industry, we are doing a poor job of making the decision to go around when an approach clearly does not meet an operator's stabilized approach criteria, despite the fact that unstable approaches are the number one factor in runway excursions on landing.

From a psychological perspective, there are once again a myriad of reasons to explain this phenomenon:

- **The myth of saving a bad approach** – As pilots, we often demonstrate an unfounded level of confidence in our own abilities to correct a bad situation. Numerous studies indicate that, in general, men tend to be more overconfident than women. The misguided notion that "I can save it" has led more than one pilot to continue an unstable approach to landing. Additionally, when this happens at a long, forgiving runway without incident, the overconfidence is reinforced, and a similar decision is more likely to be made in the future.
- **Embarrassment at admitting failure** – Similarly, admitting that an approach is unstable is also an admission of failure to properly manage the energy state of the aircraft. Failure is a difficult thing to accept and can cause a pilot to reject the idea outright. Instead, choosing to "save" the approach.
- **Mission orientation** – Most pilots are focused on completing the mission and doing so on time. Business aviation pilots may actually be more mission-oriented than their airline counterparts because of the close relationship they often have with passengers, and the understanding of the importance of getting them to a scheduled meeting on time. This alone can create tunnel vision towards completing the mission on time. Sidney Dekker, in his book "The Field Guide to Understanding Human Error," refers to this phenomenon as plan continuation bias and defines it as, "…sticking to an original plan while the changing situation actually calls for a different plan." Additionally, it is human nature to feel a greater need to complete the mission as the end of the mission gets closer. As landing represents the completion of the mission, it stands to reason that a pilot who is on final approach is feeling the peak desire to complete the mission and avoid the time needed to execute a go-around and second attempt.

As the adage suggests, nobody's perfect. A superior aviator will recognize when he or she has placed the airplane in a precarious energy state and elect to go around. A superior operator will likewise adopt a "no fault go-around policy" (as suggested in section 5.8 of the FSF Go-Around Decision-Making and Execution Project), whereby pilots are rewarded for making the decision to go around and passengers are provided with the very appropriate explanation that, while inconvenient, a go-around is far better than the alternative.

1.2.3 The Lemming Effect

It is not uncommon in aviation to hear a pilot ask an air traffic controller things like, "Is anyone else getting in?" or "Is anyone else going through that weather?" As humans, when we are faced with a difficult decision, it is in our nature to assess what others in a similar situation are doing in order to ease the burden of the decision itself. In effect, letting the majority influence our final decision instead of making it independent of the actions of others. In psychology, this is known as the Lemming Effect, named after the myth that lemmings in arctic regions will follow each other off of a cliff. Many psychologists even argue that humans are conditioned by nature to follow the larger group's actions instead of risking independent decision-making as it provides a ready-made defense if things go poorly.

Fortunately, parental wisdom provides a quick and easy antidote to the Lemming Effect. We've all been asked by a parent, "If your friends all jumped off a bridge, would you follow them?" When considering a takeoff or landing under less-than-ideal weather conditions, particularly where surface conditions are compromised, it may be wise to remember your parents' wisdom and not follow the aircraft ahead of you.

1.2.4 The importance of phraseology

Many operators have developed standard callouts for various phases of flight to indicate a crew member's understanding and/or intentions to the other crew member. It is possible for a word or phrase to create an expectation that the pilot flying intends to do something, regardless of the circumstances. For instance, when conducting an instrument approach during low weather when the airport will only be spotted shortly before touchdown, a pilot flying, who, upon visual acquisition of the airport states, "Visual, landing," has created an expectation that a landing will occur. An alternative phrase, such as, "Visual, continuing," alters the intent and allows for the possibility that a go-around could still occur if the landing is deemed unsafe for any reason. It may seem like simple semantics, but phraseology has a significant impact in training our brain on what to expect.

1.3. GO-AROUND NON-COMPLIANCE

According to the Flight Safety Foundation's report, Reducing the Risk of Runway Excursions, an unstable approach and touching down long and/or fast are the top two contributing factors to a runway overrun on landing, compounded by the failure to execute a go-around when either of these factors are present. Furthermore, the Flight Safety Foundation's Go-Around Decision-Making and Execution Project points out the following: "Approach and landing is the most common phase of flight for aviation accidents, accounting annually for approximately 65% of all accidents. A Flight Safety Foundation study of 16 years of runway excursions determined that 83% could have been avoided with a decision to go around. In other words, **54% of all accidents could potentially be prevented by going around**." This report goes on to highlight that only about 3% of unstable approaches result in the execution of a go-around.

To better understand the psychology behind this lack of compliance with go-around policies, the Flight Safety Foundation engaged the Presage Group to conduct research into the psychology of non-compliance by flight crew members and the psychology of management's handling of go-around policymaking. The results can be found in section 3.3 of the report, but highlights include a general acceptance of policy non-compliance, flight crews' lack of awareness of the risks of continuing an unstable approach to landing, and unrealistic go-around policy criteria.

Recommendations from the report include the following:

- **The policy must make sense** – Many flight crews interviewed believe that the widely-accepted stabilized approach policies in use are overly-restrictive and therefore do not compel a go-around because the crews intuitively believe that they can still save a bad approach even below the gates most often in use (500' AGL on a visual approach, 1,000' AGL on an instrument approach). To combat this, the report provides suggestions for industry validation to update current stabilized approach gates to more realistic heights above touchdown with compelling data to support their suggestions (section 10.3).
- **The policy must be managed effectively** – Management must establish targets for compliance and initiatives to achieve those targets.
- **Increase awareness** – Management must provide awareness of the risks of go-around non-compliance and its contribution to approach and landing accidents, as well as increasing situational awareness throughout approach and landing through policy enhancements, communication improvements, and reducing the subjectivity of go-around decision-making (i.e., either crew member can call for a go-around without fear of retribution).

Along with employing a no-fault go-around policy, enhancements to stabilized approach criteria and compliance targets provide a significant opportunity to reverse the trend of failing to go around when conditions warrant.

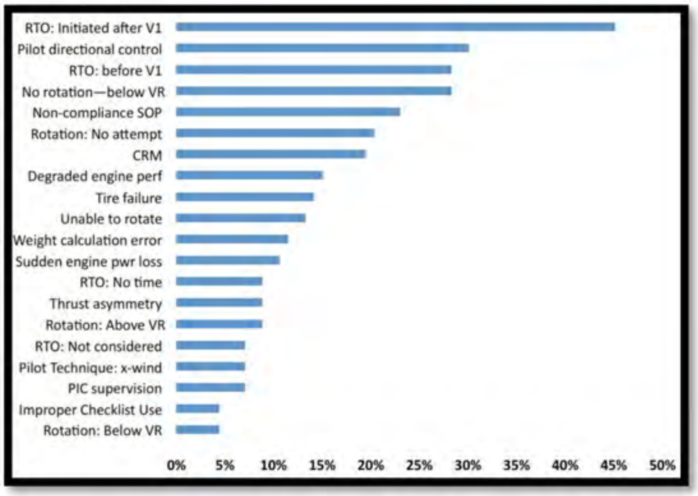
SECTION 2

Runway Excursions on Takeoff

2.1. FACTORS LEADING TO RUNWAY EXCURSIONS ON TAKEOFF

According to the Flight Safety Foundation's Reducing the Risk of Runway Excursions report, runway excursions on takeoff only account for 21% of all runway excursions. However, because of the extremely short time available for decision-making that must occur during this critical period, it is the more challenging type of runway excursion to prevent.

The following are factors that have led to runway excursions on takeoff:



Source: Flight Safety Foundation, Reducing the Risk of Runway Excursions

- **Performance-related** – Failure to properly calculate the effects of aircraft weight, outside air temperature, and airport elevation.
- **Weather-related** – Gusty crosswinds that lead to veer-offs; departing with a tailwind that exceeds aircraft limitations.
- **Surface-related** – Narrow runway (especially combined with strong crosswinds); frozen contaminants limiting traction during an abort.
- **Aircraft-related** – System failures leading to directional control issues.
- **Human-related** – Failure to properly configure the aircraft for takeoff; aborting beyond V1; fatigue/response time/improper response.

The Flight Safety Foundation also looked at how risk factors interacted together to increase the risk of a veer-off or runway overrun. They found a higher risk of runway veer-offs associated with RTOs that were conducted above V1 speed following an engine failure, with runway contamination present, and with issues surrounding weight and balance/performance calculations. When looking at runway overruns, they found an increased risk of an overrun associated with RTOs below V1 speed involving an engine failure on a contaminated runway where either a crosswind or wind gust/turbulence/windshear was present. The takeaway is that risk increases when more than one adverse risk factor is present. Therefore, each takeoff should be evaluated carefully in the totality of circumstances present and risks carefully evaluated accordingly.

2.1.1 Performance factors

In order to ensure an aircraft can become airborne within the distance available under the given conditions, a proper calculation of all performance factors must be completed prior to advancing thrust on the takeoff roll. While this sounds fairly straightforward, correct calculation of all factors can be challenging.

Aircraft manufacturers are required to publish an airplane's takeoff performance data based on results obtained during the flight testing that led to the airplane's certification. It is important to understand how that data is obtained so that the crew can replicate it if they hope to achieve similar results. For instance, most manufacturers achieve their takeoff performance data by performing a static takeoff, using brakes to hold the plane in position until the engines are stabilized at takeoff power. This information can be found in the performance section of the approved Airplane Flight Manual. It is also important to understand that the takeoff distance data published in the AFM does not include any additional safety margin, although it does include time delays for the execution of the takeoff or rejected takeoff procedures that may be reasonably expected during line operations.

Furthermore, most takeoffs occur under routine conditions that don't require special considerations and, as a result, pilots may not be proficient at recognizing, including, or properly calculating any non-standard takeoff factors. Modern technology allows accurate performance calculations to occur in a matter of seconds, provided the information input is correct and complete. However, if weather-, surface-, or aircraft-related factors are not included, or not properly input, the resulting performance calculation will be incorrect. For example, using a wet factor when, in fact, there is more than 1/8" of standing water on a non-grooved or non-porous friction course (PFC) runway surface could produce very misleading results. Similarly, in active frozen precipitation, runway conditions can change rapidly and using the factor reported on the most recent ATIS may also lead a pilot to believe that a takeoff is possible when deteriorating conditions would, in fact, prevent it.

One very practical recommendation from the Flight Safety Foundation's Global Action Plan for the Prevention of Runway Excursions is to have both crew members (in a multi-crew airplane) conduct independent performance calculations for comparison. This is particularly worthwhile in challenging conditions, to ensure the accuracy of the calculations and that both are comfortable with the performance required relative to the amount of runway available. Single-pilot operators can accomplish the same thing by having a trusted source not operating the flight review their performance calculations prior to departure.

Operators may also want to consider applying a safety margin between the takeoff performance calculated and the amount of runway available for the takeoff.

2.1.2 Weather factors

Weather has led to numerous runway excursions. We generally think of the effects of wind during approach and landing, but wind can have an equally devastating effect during takeoff.

A strong crosswind on takeoff could exacerbate the difficulty of controlling an aircraft that loses an engine during the takeoff roll just prior to the minimum controllable ground speed (Vmcg) if the crosswind is blowing from the same side as the failed engine. During Vmcg certification testing, the airplane's ground track is permitted to deviate from the runway centerline up 30 feet, but no consideration is given for the effect of any crosswind component. The weathervane effects of a crosswind would combine with the adverse yaw created by the operating engine and, at or below Vmcg, the rudder may lack the authority to counteract this turning tendency, leading to a runway veer-off.

In February 2022, a Hawker 800XP experienced a runway overrun after an aborted takeoff at Colorado's Aspen/Pitkin County Airport (ASE) when the crew realized the airplane would not become airborne. In its final report, the NTSB discovered that the tower controller provided the crew with an "instantaneous wind" report just prior to takeoff that indicated the winds were just barely within the 10-knot tailwind limitation for the Hawker. However, the rolling two-minute average wind readouts obtained before and after the accident indicated that these average winds were significantly stronger than the plane's 10-knot tailwind limit. As probable cause, the NTSB cited the crew's "improper decision to takeoff in tailwind conditions that exceeded the airplane's performance capabilities, which resulted in a runway overrun following an aborted takeoff."

2.1.3 Surface factors

Given the high reliability of modern aircraft systems and jet engines, it is reasonable to assume that every takeoff attempt will result in successfully becoming airborne. Consequently, pilots may be apt to give only nominal recognition of the runway needed to abort a takeoff at high speed on a contaminated surface. While a flight crew would be correct in assuming that the odds of becoming airborne are drastically in their favor, that still falls short of a guarantee. It is within this very narrow window of probability that we find the incidence of runway excursions where standing water or frozen contaminants are a contributing factor. According to data from the Flight Safety Foundation's Reducing the Risk of Runway Excursions, contaminated surfaces were the second leading cause of runway overruns – even when aborting below V1 – and the third highest contributing factor to runway veer-offs during takeoff.

It is also worth considering how runway surface conditions are disseminated to crews and the limitations therein. In October 2016, the FAA implemented a new system to report surface conditions. (Only Part 139 and federally obligated airport operators are required to report runway conditions.) This new system created the Runway Condition Assessment Matrix (RCAM) a standardized method for assessing and reporting a runway's contamination type and depth using the same terminology that is used in the supplemental contaminated runway takeoff distance performance data. Following implementation of the RCAM, Field Condition NOTAMs (FICONS) and ATIS broadcasts now report a runway's contamination type and depth for each third of the runway surface. For example, "ORD RWY 09R FICON 5/5/3 100 PRCT 1/8IN SLUSH, 100 PRCT 1/8IN SLUSH, 100 PRCT 1/4IN WET SN." Using the new RCAM, the reported runway contamination type and depth should directly correlate with the contaminated runway takeoff performance data provided by the manufacturer. In this example, the first two thirds of runway 09R are simply wet and are not considered "contaminated." However, the last third of the runway is considered "contaminated" with ¼ inch of wet snow.

While the RCAM has simplified the ability for crews to assess the effects of runway contamination on their takeoff performance, there are still limitations that must be understood. Part 139 airports with commercial airline service are required to maintain their runways in a condition no worse than "wet," to continuously monitor those runways for deteriorating conditions, and report the most current runways conditions through FICON NOTAMs. Other airports may not be able to monitor and report runway conditions with the same frequency, and some not at all after normal working hours. During rapidly changing conditions, for example, if active frozen precipitation is falling and increasing in intensity, the FICON reported 15 minutes ago may no longer be valid. Crews must account for rapidly changing weather conditions during their takeoff performance planning and consider delaying or canceling a flight until the current FICON information can be obtained.

The width of the runway surface should also be a consideration. If, while departing from a narrow runway with a strong crosswind, an engine fails just prior to Vmcg (minimum controllable ground speed) on the side from which the wind is blowing, these combined factors could easily lead to a runway veer-off while the crew is contending with the engine failure and subsequent abort. Some aircraft manufacturers have published recommendations for minimum runway width and special procedures that should be employed if an operator intends to utilize a runway that falls below this threshold. And, similar to crosswind limits while operating from contaminated surfaces, some operators also place limits on maximum crosswinds that are well below the maximum demonstrated crosswinds published in the AFM when operating from narrow runways. Likewise, prohibiting operations from a runway that is both narrow and contaminated eliminates the need to deal with both risk factors at once.

Creating a safety buffer is the best way to mitigate the risks of controllability issues on narrow or contaminated runways.

2.1.4 Aircraft factors

During the period studied by the Flight Safety Foundation, it was noted that 17 total veer-offs and 12 total overruns followed an engine failure on takeoff. Unfortunately, the training requirement is to only practice engine failures at V1, with the expectation that the crew will get the plane airborne. Most takeoff aborts practiced below V1 are at such a slow airspeed that the learning is minimal. We will discuss more realistic training scenarios in a later section.

While engine failures garner the most attention as it relates to runway excursions on takeoff, there are other aircraft systems that have contributed to some noteworthy accidents. In fact, non-engine-related failures account for the majority of all rejected takeoffs, according to the FAA's Pilot Guide to Takeoff Safety.

A tire failure just after V1 on a Learjet departing from South Carolina's Columbia Metropolitan Airport (CAE) in 2008 led to the captain making the ill-fated decision to abort the takeoff, resulting in a runway overrun that destroyed the airplane in a post-crash fire, killing four of the six occupants. While there was certainly a human factors element involved in the decision to abort the takeoff beyond V1, the exploding tires are what precipitated the decision. (Human factors are discussed in the next section.) The NTSB report noted that the tires of the Learjet were significantly under-inflated, causing two main tires to explode at high speed.

In 2017, an MD-83 departing from Michigan's Willow Run Airport (YIP) rejected a takeoff after V1 when the captain could not get the airplane airborne. The NTSB report noted that half of the horizontal stabilizer had become jammed as a result of the airplane sitting in high winds for several days prior, with the stabilizer flapping around in the wind. (The MD-83 was not designed with an elevator gust lock system.) Although the airplane was damaged beyond repair in the accident, all aboard survived with only minor injuries.

Both of these accidents occurred following an aborted takeoff beyond V1 under very different scenarios (one could have become airborne, the other could not) and with different results, but both resulted from non-engine-related system failures. The decision to abort beyond V1 – or at any time in a high-speed portion of the takeoff roll – is something that should be given considerable thought and practice in a simulator. This will be discussed in detail in a later section.

2.1.5 Human factors

Aircraft are designed, built, maintained and operated by humans – and humans make mistakes. In the 120+ years since the Wright brothers first took to the skies, the aviation industry has learned a great deal about the limitations of the humans that interact with these complex machines. Consequently, checklists have been developed to ensure that aircraft are properly configured for each phase of flight. As an added layer of protection, warning systems have been added to alert the pilot that the takeoff configuration is not correct. Takeoff briefings have been developed to discuss actions to be taken in the event of a malfunction during the takeoff roll. Data on the effects of wind and surface conditions has been gathered and published for flight crew performance planning. And yet, forgetting checklists or overlooking checklist items, improperly configuring the aircraft for takeoff, overriding takeoff configuration warning systems, failing to adhere to takeoff abort criteria and briefings, and ignoring signs that the weather or surface is unsuitable for takeoff have all been identified as contributing factors in runway excursions that occurred during the takeoff phase of flight.

Fixation, omission and distraction are all regular threats to operations on the flight deck. Operators who adhere to a sterile cockpit rule do so to minimize distractions. At a bare minimum, adherence to checklist usage – paper or electronic – reduces the chance of missing a critical item prior to takeoff. These things are all done with an awareness that the human brain can only process one item of information at a time, thus making it imperative that the brain is focused on the task at hand or brought back quickly to the task at hand if something unexpected occurs to divert attention.

Fixation and omission occur inadvertently and without conscious choice. Likewise, if a system failure occurs during the high-speed portion of the takeoff roll (above or below V1), the startle factor may induce an unconscious and undesirable reaction from the pilot flying, which, as has been documented, could lead to a runway excursion (Flight Safety Foundation data indicates that, during the period studied, 51 runway excursions occurred following an aborted takeoff above V1, accounting for the most common cause.) The best defense against this natural human proclivity is to adopt a takeoff briefing and abort protocol that removes as much ambiguity and split-second decision-making as possible, leaving the pilot's mind free to concentrate on a much simpler logic of going or stopping. Some Part 142 training providers offer advanced takeoff go/no-go decision-making courses that go above and beyond what is required by the FAA to meet recurrent training requirements. Operators can also review the FAA's Pilot Guide to Takeoff Safety in order to develop a better understanding of appropriate RTO criteria.

In opposition to unconscious mistakes that are allowed by the human brain, aviation history is replete with examples of well-trained, professional flight crews making conscious decisions that, in retrospect, are difficult to believe. However, these choices continue to be made. So, in order to learn from this pattern of behavior one must first admit that we, as humans, are all susceptible to mission fixation and, under the right circumstances, may make similar choices in an effort to complete the mission. Once a pilot recognizes their susceptibility to this temptation, they are better able to identify it when it happens and then force themselves and their fellow crew member to stop and re-evaluate their decision tree before a takeoff is initiated that may end poorly.

Every pilot that has ever silenced or disarmed a warning system did so because the system was a nuisance, without due consideration that at some point, when it's most needed, that system could prevent a tragedy. Every pilot that has ever departed in weather conditions that were temporarily advertised as being within the airplane's limitations did so in an effort to get themselves and their passengers to their destination, without regard for the very dynamic and unforgiving nature of the environment in which we operate. And every pilot who has operated aircraft long enough to fly professionally has likely made a conscious decision that, in hindsight, they tell themselves to never do again. It is incumbent upon professional aviators to learn from their own mistakes and those of others before them in order to preclude known human factors from leading to a runway excursion.

2.2. A DISCUSSION ON V_1

There have been numerous references to V_1 throughout this guide. But what is V_1? Ask 10 pilots and expect 10 answers that likely involve some variation of "takeoff decision speed". Is this correct?

According to Part 1 of the Federal Aviation Regulations, V_1 is defined as "the maximum speed in the takeoff roll at which the pilot must take the first action (e.g., apply brakes, reduce thrust, deploy speed brakes) to *stop the airplane* within the accelerate-stop distance. V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at VEF, at which the pilot can *continue the takeoff* and achieve the required height above the takeoff surface within the takeoff distance [emphasis added]." It should be noted that this current definition of V_1, implemented in the late 1990s to replace the prior definitions of "critical engine failure speed" and "takeoff decision speed", creates a barrier between two possible actions: abort the takeoff or continue and become airborne. The old definition implied that a "decision" is made a V_1 speed. The current, and correct definition implies that the first "action" to reject must occur no later than V_1 speed. While this may seem like semantics, the devil is in the details.

According to the current definition, if a pilot is to abort a takeoff and stop within the calculated accelerate-stop distance – which is required to be equal to or less than the Accelerate-Stop Distance Available (ASDA) – this action must be initiated *no later than* V_1. It stands to reason then, that the decision must be made prior to reaching V_1 in order to meet the performance required to avoid a runway overrun. Furthermore, if the decision to abort or continue must be made prior to V_1, the pilot flying must therefore know that V_1 is approaching prior to actually reaching it. To that end, the pilot monitoring should make the V_1 callout just prior to reaching that speed, because, once reached, the only viable action is to continue the takeoff and become airborne. Unfortunately, the older "takeoff decision speed" definition of V_1 has, like most aviation legends, refused to vacate the aviation lexicon, thus leading to ongoing confusion over when, *exactly*, an abort can be executed with reasonable likelihood of stopping within the remaining pavement.

An astute reader may argue that there are times when an aborted takeoff beyond V_1 can be successfully completed when the ASDA is significantly greater than the calculated accelerate-stop distance required for the given conditions. For example, if the calculated accelerate-stop distance is 4,750' and the ASDA is 9,000', an aborted takeoff beyond V_1 is more likely to end successfully than if the ASDA is only 5,500'. However, for every second that the airplane is allowed to continue accelerating beyond V_1 before the abort is initiated, the ASDA is being used up at a very high rate. At 150 knots, the airplane is covering 253 feet/second. Further acceleration to 160 knots covers 270 feet/second. Furthermore, if V_1 was calculated at 135 knots, the distance to stop the airplane was predicated on initiating the abort no later than reaching that speed. At 160 knots, the total stopping distance is significantly longer, and more importantly, is an unknown quantity. Is there enough brake energy to complete the abort? Will the tires or fuse plugs blow? In other words, aborting beyond V_1, even on a long runway, puts the crew in an unknown situation – effectively attempting something with an unknown outcome and very high stakes for getting it wrong.

One easy way to create more of a buffer is to use a larger flap setting. Most manufacturers provide takeoff data for multiple flap settings. By using a larger flap setting, stalling speed is reduced thus reducing both V_R and V_2 speed. In turn, this reduces the accelerate-stop and accelerate-go distances, which provides a greater buffer between the performance requirements and the pavement available. The one caveat to this procedure is that the larger flap setting can reduce initial climb performance following an engine failure and may adversely affect terrain and/or obstacle clearance along the departure path.

Having a better working knowledge of V1 is one more way to mitigate the risks of a runway excursion on takeoff.

For additional information, the FAA Transport Airplane Performance Planning Working Group (TAPP WG) has created four videos that address takeoff performance planning.

TAPP WG Video (Part 1 of 4): Planning For Takeoff Obstacle Clearance

TAPP WG Video (Part 2 of 4): Declared Distances

TAPP WG Video (Part 3 of 4): Wet Runway Takeoff Performance

TAPP WG Video (Part 4 of 4): Landing Distance Assessment

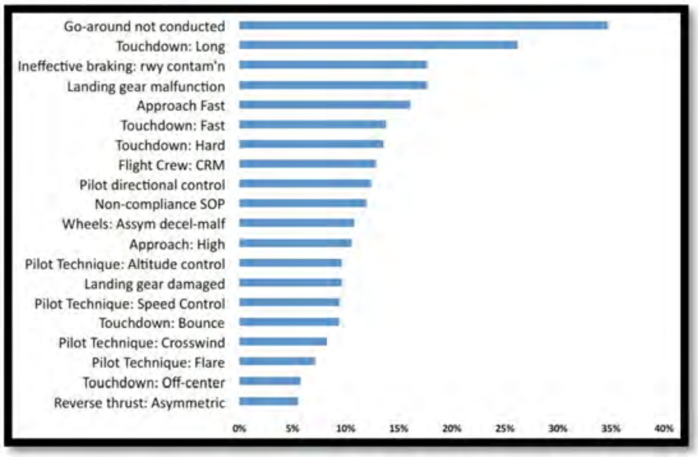
SECTION 3

Runway Excursions on Landing

3.1. FACTORS LEADING TO RUNWAY EXCURSIONS ON LANDING

According to the Flight Safety Foundation's Reducing the Risk of Runway Excursions report, runway excursions on landing account for 79% of all runway excursions, and nearly all of the leading factors are completely preventable.

The following are factors that have led to runway excursions on landing:



Source: Flight Safety Foundation, Reducing the Risk of Runway Excursions

- **Performance-related**—Failure to properly calculate the effects of aircraft weight, outside air temperature, and airport elevation; not recognizing when LDA is less than the overall pavement.
- **Weather-related**—Gusty crosswinds that lead to veer-offs; landing with a tailwind that exceeds aircraft limitations.
- **Surface-related**—Narrow runway (especially combined with strong crosswinds); frozen contaminants limiting traction during the rollout.
- **Aircraft-related**—System failures leading to directional control issues; improper configuration; MEL items.
- **Human-related**—Non-compliance with stabilized approach and go-around policies; bounced/hard touchdown; extended flare; poor braking technique.

During the study period, data shows that runway veer-offs during landing were most common following a stabilized approach but were most often compounded by a contaminated surface that provided inadequate steering and braking. Not surprisingly, runway overruns were most commonly caused by touching down long and/or fast, with failure to conduct a go-around as the most common compounding factor. 65% of long/fast touchdowns occurred following an unstable approach.

3.1.1 Performance factors

Just like calculating takeoff performance, in order to ensure the airplane will stop in the distance available, landing performance must be calculated with the most current conditions. And, just like takeoff data, it is important for the pilot and operator to understand the techniques applied during the certification process to achieve the data.

The landing distance data published in the AFM may be determined using several different methods, depending on the regulations under which the airplane was type certificated. In all methods, the landing distance can be broken down into three distinct phases:

- Air distance from 50′ above the runway to touchdown,
- Transition distance from touchdown to the point where the airplane is in the full stopping configuration, and
- Ground stopping distance where the aircraft is brought to a complete stop.

For a variety of reasons, these methods are generally designed to reflect the maximum achievable capability of the aircraft. The methods are typically not operationally representative, but they form an objective boundary on capability that can be common across multiple aircraft types. It is left to the operator (or operational regulations, as applicable) to adjust the limiting capability of the aircraft to operational practice(s).

The air distance may be calculated from an analytical model built by the manufacturer from flight test data collected for a variety of descent angles and touchdown rates, and then expanded out to determine the air distance associated with a 3.5 degree descent angle and an 8 ft/sec. touchdown rate. It may also be calculated using a simpler approach measuring actual air distances and flare times from approaches averaging 3.0 degrees (data for angle greater than 3.0 degrees may be published as well) and touchdown rates averaging up to 6 ft/sec. Regardless of the methods utilized, they typically produce air distances from 800 to 1200 ft, so operational techniques resulting in touchdown beyond this distance will exceed the AFM assumptions. While touching down near or just beyond this distance is operationally achievable from a well-stabilized approach at a speed near VREF, as highlighted previously, most runway overruns begin by grossly exceeding this air distance allowance.

Transition distance is determined from the time required during the flight test demonstration to de-rotate the aircraft and fully activate each deceleration device (e.g., brakes, spoilers). A minimum time delay of 1 second is required for each device except those that are automatically actuated (e.g., autospoilers). The aggressive techniques employed by manufacturers in this phase can frequently result in a transition time allowance as low as 1-2 seconds for many business jet aircraft. During this segment of the landing, most aircraft are traveling at a speed of nearly 200 ft per second, so each second beyond this short allowance in operational practice will add 200 feet to the AFM distance.

The final segment, ground stopping distance, is determined with each deceleration device fully activated. This includes maximum effort braking limited by the anti-skid system, or selected levels of autobraking, if equipped. In this state of maximum braking most business jets are capable of achieving decelerations approaching 0.5g, and the resulting stop may be completed in 10 to 15 seconds in a distance as short as 1,000 ft. For propeller airplanes, the “disking drag” afforded by reversible propellers may be included in the stopping distance. However, for turbojet airplanes, the use of thrust reversers is typically not included, as they could only provide minimal benefit in the short stop time under maximum effort braking. These techniques reflect the maximum achievable capability of the aircraft but create the most significant deviation between the AFM and typical operational practice, where deceleration may be modulated by the pilot to a more comfortable level with a resulting stopping distance and time nearly double that assumed by the AFM.

Lastly, the AFM data provided by the manufacturer assumes a speed at 50′ above the runway precisely at VREF. Operational practices frequently target approach speeds in excess of VREF, and this extra speed will add distance to each of the three segments above. The most significant of these is the increase to the stopping distance, where the increase will be with the square of the initial stopping speed. A landing distance increase of up to 20% may occur for a typical business jet approaching at VREF + 10 knots.

All landing distance data published in the AFM requires accountability for a smooth, dry, hard-surfaced runway factoring in 50% of the headwind component and 150% of the tailwind component. The data provided need only account for a standard day temperature at the airport elevation. Part 23 Commuter Category aircraft are required to account for runway slope, and some manufacturers may provide these and/or non-standard temperature corrections at their discretion. For detailed discussion on landing distance certification, see NBAA’s Airplane Performance and TALPA briefing.

The operating regulations in 14 CFR parts 121, 135 and 91K require turbojet operators to be able to land within 60% of the runway’s Landing Distance Available (LDA) prior to dispatch and as this is applied as a limitation on the maximum allowable takeoff weight. This is accomplished by multiplying the certificated, dry runway landing distance obtained from the AFM by 1.67 (alternatively, divide it by 0.6). If the runway is forecast to be wet or slippery at the estimated time of arrival, this factored distance is increased by an additional 15%. Some 14 CFR part 135 and 91K operators have been granted Operations/Management Specifications allowing them to dispatch to land within 80% of the dry runway LDA, or a factor of 1.25 (100/80=1.25). Part 91 operators not subject to these dispatch requirements. However, part 91 operators would be prudent in adopting these same dispatch requirements since the basic premise behind the certification requirements for determining the dry runway, unfactored landing distance for a part 25, transport category airplane typically assumes that these dispatch requirements are applied to the operation.

These dispatch rules are intended to provide a reasonable expectation that the airplane will arrive overhead the destination or alternate airport at a weight that will permit a safe landing based on the forecast conditions at the time of dispatch. Any assumptions made in that assessment prior to departure, specifically regarding weather and runway conditions, should be verified as still accurate prior to attempting a landing at that airport, and if not, a reassessment should be made accounting for the changes. This is accomplished by performing a landing distance time of arrival (LTDA) assessment, as described in 3.2.

The runway's LDA is part of the runway's declared distances (see AIM Section 4–3–6. Use of Runways/Declared Distances). The LDA may or may not be the same as the published runway length. When it is less, it is often due to either a displaced threshold at the approach end or use of the runway at the rollout end to meet runway design standards. For example, the Chart Supplement entry for Naples, FL, (APF) shows that runway 14 is 5,001′ with a displaced threshold of 128′. However, the LDA for this runway is 4,420′. A portion of the rollout end of this runway is being used to satisfy runway safety area design standards. Pilots must base their landing performance calculations on the published LDA for a runway. Where the declared distances and the LDA are not published, the pilot may assume the LDA to be the full runway length less any displaced threshold.

In conclusion, it is imperative that pilots and operators understand how the performance for their airplane was obtained, using the LDA (not runway length), and applying a safety margin that is consistent with their overall operating philosophy or regulatory requirements in order to account for landing performance that will not match what the test pilots obtained. Additionally, as recommended by the Flight Safety Foundation's Global Action Plan for the Prevention of Runway Excursions, both crew members should conduct independent landing performance calculations for comparison, especially when conditions are less than ideal. Single pilot operators can utilize a third party not operating the flight to review their performance calculations prior to dispatch. However, as discussed in 3.2, accomplishment of a time of arrival landing performance assessment will need to be conducted by the single pilot alone, therefore requiring extra diligence in reviewing all variables.

3.1.2 Weather factors

Perhaps the most prevalent weather condition that pilots contend with on nearly every landing is wind. Strong, gusty winds, especially when not aligned with the landing runway, present a challenge to obtaining the calculated runway performance. The Flight Safety Foundation's Approach and Landing Accident Reduction (ALAR) Tool Kit notes that a 10% increase in airspeed when crossing the runway threshold creates a 20% increase in landing distance (assuming normal flare and touchdown). As an example, starting with a calculated VREF of 110 knots and a calculated landing distance of 3,000′, a pilot who carries an extra 10 knots (9% additive) to account for gusty winds will add 545′ (18% additive) to the calculated landing distance. Adding even a modest 15% safety margin (assuming the runway is dry, more on that in section 3.13) adds another 532′ for a total of 4,076′. This would quickly take that 4,000′ runway out of contention on a gusty day.

The ALAR Tool Kit Briefing Note 8.3 also notes that a 10-knot tailwind adds 20% to the calculated landing distance. Failure to account for the tailwind component in the runway performance software and/or flight management system (FMS) would be a 600′ mistake in the previous example of an initial 3,000′ landing requirement. And beware of a calm winds report. Calm winds reported by the tower can be as high as three knots in any direction, which may be a tailwind.

The other weather factor that can have a significant effect on landing performance is landing with the anti-ice system on. The certification rules require manufacturers to account for landings in icing conditions, including additional landing distance required with ice protection systems operating or as result of any required increase VREF speed accounting for ice accretion on the airplane. Failure to check the "anti-ice on" box when calculating landing performance could lead to a lower-than-desired stall margin if, in fact, there is residual airframe icing and the "anti-ice off" VREF is used. Conversely, failing to account for icing conditions on approach when calculating landing distance prior to dispatch, then correctly turning the anti-ice on during the subsequent approach without recalculating the landing distance, could also place the airplane and its occupants in danger of a runway overrun due to the higher approach speeds.

3.1.3 Surface factors

Manufacturers have in the past provided supplementary advisory landing distance data for conditions beyond those required by regulation. This advisory, contaminated data is not FAA-approved and should be viewed as supplemental only. This landing distance data has been replaced by the TALPA/GRF Operational Landing Distance data which should be used for the time of arrival landing distance assessment.

As noted earlier, the FAA approved AFM, unfactored landing distance is based on smooth, dry runway. The FAA permits manufacturers to also furnish FAA-approved wet runway landing distance data for use on grooved or PFC runway. This data is intended to be used in lieu of increasing the 14 CFR dry runway 60% factored landing distance by an additional 15% if the runway is forecast to be slippery or wet. However, before using this data, the operator must ensure that the grooved or PFC runway meets the FAA runway design and maintenance standards. If the FICON is issued for runway that states "3/3/3 SLIPPERY WHEN WET," it is an indication that the runway no longer meets these design standards and that this data cannot be used. The operator must increase the 60% factored landing distance by an additional 15% when applying the dispatch rules to the maximum allowable takeoff weight. This data should not be used for the time of arrival landing distance assessment.

Operating on the backside of the clock? You might see a note in the Chart Supplement or on the Jeppesen 10-9A for your airport of intended landing referencing that runway conditions are not monitored during certain hours when the airport is not staffed. In addition, a NOTAM may be issued if the airport is temporarily unable to report or monitor runway conditions for any reason: "CWA CWA AD AP SFC CONDITIONS NOT REPORTED 1701062200-17090500" or "!LGA LGA RWY 13 FICON 1/1/1 100 PRCT ICE OBSERVED AT 1701040230. CONDITIONS NOT MNT 1701040300-1701050300." In either case, you're on your own to assess the runway conditions.

Crews should endeavor to find the most up-to-the-minute runway conditions prior to landing or consider diverting if they suspect conditions have worsened since the RwyCC was issued. For operators who wish to develop a TALPA program, NBAA put together a great video learning series on TALPA, which can be viewed here. The FAA provides guidance on TALPA in AC91-79B.

What about the runway itself? A grooved or porous friction course (PFC) runway is designed to dissipate water quickly to avoid the threat of standing water and associated hydroplaning. This information can be found in the Chart Supplement (formerly A/FD). If a runway is not grooved or PFC and moderate or heavy rain is present or recently passed through, crews should anticipate standing water and adjust their landing performance calculations accordingly. The FAA considers a runway with more than 1/8" of standing water to be contaminated. A Beechjet crew, landing at Georgia's Macon Downtown Airport (MAC) in 2012, discovered that the non-grooved runway was contaminated with standing water following heavy rainfall that had recently passed over the airport. That, combined with an approach speed that was 15 to 19 knots above VREF, and a steeper-than-normal approach angle, resulted in a runway overrun. Even runways that are grooved or PFC can be overwhelmed when heavy rain is present. The FAA describes this threat to turbine-engine, transport category airplanes in AC91-79B. When heavy rain is reported or occurring at the time of landing, pilots should consider using a RwyCC of "2" whenever there is the likelihood of moderate or greater rain on a smooth runway or heavy rain on a grooved/PFC runway.

Runway slope can also play a part. Runway performance providers include this information automatically from their database of published runway information. However, that's not always the whole story. The Chart Supplement for Runway 6-24 at North Carolina's Hickory Regional Airport (HKY) shows 0.8% up NE slope. So, landing on 24 will be slightly downhill. However, the reported slope is based on the rise over run from one end of the runway to the other and does not necessarily account for what's in the middle. A new operator at HKY might be surprised to find that the runway appears to slope slightly upwards through the first 1,000′ followed by a significant downslope until the last 1,000′ where it flattens out. A crew who does not touch down by the 1,000′ markings may find themselves "chasing the runway" as it slopes quickly away. An operator with a touchdown point limit (discussed in section 3.2) will initiate a go-around once too much pavement has passed by, but another operator may try to force the plane onto the runway and realize too late that the end of the pavement is fast approaching.

Finally, a narrow runway can add another layer of difficulty for a flight crew during landing. Much like taking off from a narrow runway, landing on one also minimizes the pavement available for lateral corrections after touchdown. This can be further complicated by a contaminated surface where nosewheel steering is degraded, and by a significant crosswind component. Here again, pilots and operators should consider restrictions on maximum crosswind components and surface contaminants when using narrow runways in order to minimize the likelihood of a runway veer-off.

3.1.4 Aircraft factors

On December 11, 2019, a Global Express experienced a nosewheel steering failure during the landing rollout at UK's

Liverpool Airport (EGGP). As a result, the nosewheel went into free caster mode and the plane began to drift towards the right side of the runway. In attempting to correct for this, the captain applied full left rudder but also inadvertently applied some right rudder pressure as well. Fortunately, the airplane received only minor damage and the occupants were unharmed as the airplane departed the side of the runway. However, the operator recognized a deficiency in their training program and modified it to give flight crews experience in dealing with such a failure during landing roll while in the simulator.

While actual system failures on landing are rare, they do occasionally happen. Operators should be aware of any peculiarities with the aircraft type they operate and make crews aware through regular training and incident/accident review.

More commonly, aircraft systems are improperly configured or poorly understood. Older, less-automated aircraft may require manual arming of certain systems that are required to achieve calculated landing performance. For example, the Flight Safety Foundation's ALAR Tool Kit Briefing Note 8.3 estimates a 30% landing distance penalty when ground spoilers do not deploy. On June 1, 1999, an MD-82 left the runway while landing in a thunderstorm at Bill and Hillary Clinton National Airport (LIT) in Arkansas. According to the NTSB report, one of the contributing factors was ineffective braking upon touchdown because the ground spoilers failed to deploy. This failure was attributed to the flight crew: "… the Safety Board concludes that the autospoiler system operated properly and that the spoilers did not automatically deploy because the spoiler handle was not armed by either pilot before landing."

Other runway overruns have been attributed to improper use of the braking system. Anti-skid systems engage when the system detects wheel slippage due to a loss of friction between the tire and the ground. The anti-skid system is designed to momentarily release brake pressure and then immediately reapply pressure at whatever rate is commanded by the pressure on the brake pedals. Pilots have been known to release the brakes entirely when they feel the anti-skid system intermittently releasing and reapplying pressure ("pulsating"). On a slippery runway, where anti-skid is more likely to be called upon, releasing the brakes could mean the difference between stopping on the runway or off of it.

Even normal braking systems can have nuances that should be understood by the pilots. Certain brake pad materials may cause a slight delay in braking action from initial application of the brake pedals as heat quickly builds in the pads, causing a non-linear braking response to a linear application of brake pressure. On certain modern aircraft, brake-by-wire systems have also been known to create confusion and misapplication of the brakes as they conduct a built-in test immediately after brake pedal pressure is applied but before the brakes are activated.

As a reminder, most airplane manufacturers achieve the calculated braking performance by applying full brake pressure immediately after touchdown. Any delay in application or release of brake pressure during the rollout could reduce the possibility of stopping within the landing distance available.

Finally, any systems that are deferred or that fail in flight could impact landing distance and/or controllability upon landing. One item that is commonly deferred – the thrust reverser – does not get credit towards calculated landing distance on a dry runway. However, most pilots are accustomed to using reverse thrust when it's available and may be surprised at how much more braking is required if one or both thrust reversers are inoperative. Directional control with only one thrust reverser can also be a challenge, especially when combined with strong crosswinds and/or a slippery surface.

3.1.5 Human factors

Of all the factors that commonly lead to runway excursions during landing, the human factor plays the most significant role, year after year. The silver lining to this seemingly gray cloud is that runway excursions created by human errors in judgment or performance are 100% preventable.

The most common mistakes made by the human pilot or operator fall under the category of poor judgment. Deteriorating conditions or an unstable approach may be cited as a contributing factor in a runway excursion accident, but the decision to continue under those conditions is the fault of the human. Data from the Flight Safety Foundation's report on Reducing the Risk of Runway Excursions indicates that the vast majority of the accidents studied resulted from the decision to land on a contaminated runway, failure to correct an unstable approach, or failure to conduct a go-around when out of compliance with stabilized approach criteria.

When examining runway overruns specifically, the single most common factor in the Flight Safety Foundation's data was landing long and/or fast. According to data from the ALAR Took Kit, an additional 10% in airspeed produces a 20% increase in landing distance, while a long flare can add up to 30%. One could argue that this could be precipitated by either poor performance or poor judgment, depending on other variables such as wind present at the time of landing. However, this one factor (long/fast touchdown) was most often associated with an unstable approach and failure to go-around, suggesting that this too is most often a failure of judgment by the human pilot. In addition, pilots who routinely add airspeed above VREF, even in calm winds, are normalizing this deviance and creating a newly accepted baseline of performance without necessarily considering the reduction of safety margins, particularly at shorter runways.

As humans, we must be constantly vigilant against the temptation or pressure to continue to mission completion when conditions would suggest a rapidly deteriorating safety margin due to external or internal factors, lest we become victims of the psychological traps discussed in Section 1.

3.2. TALPA/GRF AND TIME OF ARRIVAL LANDING DISTANCE ASSESSMENT

3.2.1. TALPA/GRF Runway Condition Reporting

In the wake of the Chicago Midway (MDW) Boeing 737 runway excursion in 2005, the FAA and industry experts assembled under the Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee. The goal of the TALPA effort was to improve runway condition assessment and reporting, and to provide the pilot with improved landing distance data on contaminated runways that allows pilots to conduct a time-of-arrival landing distance assessment based on the reported conditions. ICAO has joined FAA in this effort by implementing their version of TALPA called the Global Reporting Format (GRF). The European Union Aviation Safety Agency (EASA) has taken this one step further by incorporating the GRF and a landing distance at time of arrival (LTDA) assessment requirement into their operating regulations.

To improve runway condition reporting, TALPA/GRF developed the Runway Condition Assessment Matrix (RCAM). There are two versions, one for pilots and one for airport operators. The airport operator uses their RCAM for assessing the runway's condition and reporting them through an FAA-issued Field Condition NOTAM (FICON). ICAO continues to use SNOTAMs to report runway conditions using the same format. For each third of the runway, FICON or SNOTAM will report the runway contamination coverage, type, and depth for use with takeoff performance calculations. For landing distance calculations, a runway condition code (RwyCC) is provided for each third of the runway. For example, at Chicago's Midway airport, on runway 31C, each third has a RwyCC of 3:

MDW RWY 31C FICON 3/3/3 60 PRCT ¼IN WET SN AND 40 PRCT WET, 60 PRCT ¼IN WET SN AND 40 PRCT WET, 50 PRCT ½IN WET SN AND 50 PRCT WET

It is important that pilots NOT use the reported contamination type and depth for their landing distance performance calculations. While the basic RwyCC is assigned using the RCAM based on the runway's contamination type and depth, the airport operator may upgrade or downgrade that RwyCC based on runway friction measurements (i.e., Mu readings) and/or subjective observations of vehicle braking or handling performance. This FICON example shows where a different airport operator downgraded the RwyCC for their runway with the same contamination type and depth:

PWK RWY 16 FICON 2/2/2 100 PRCT 1/4IN WET SN

Therefore, the RwyCC may be higher or lower than the corresponding runway contamination would otherwise indicate.

3.2.2 TALPA/GRF Landing Distance Data

During the discussion of airplane performance, the TALPA ARC noted that 14 CFR Part 25 landing distances are determined in a way that represents the maximum performance capability of the airplane, which may not be representative of normal flight operations. When this data is used in conjunction with the operating regulation in 14 CFR parts 121, 135, and 91K operators, it has proven satisfactory when the runway is dry, or it is a wet grooved/PFC runway. However, when the runway is contaminated, the minimum runway requirements specified by these operating rules have proven less than adequate for stopping the airplane. To address this concern, the TALPA ARC developed new guidance for determining landing performance data that corresponds directly to the RwyCC and that is more representative of the expected landing performance of a trained flight crew of average skill following normal flight procedures and training. This guidance is published in AC 25-32 Landing Performance Data for Time-of-Arrival Landing Performance Assessments and is used by manufacturers in developing and providing this data for the operator's use.

Landing distance data based on the guidance published in AC 25-32 differs from the advisory, contaminated runway landing distance data furnished in the AFM supplement and in the output of FMS performance functions available with most current business aviation turbojet airplanes. This earlier advisory, contaminated runway landing distance data is usually based on the 14 CFR part 25, dry runway, un-factored AFM landing distance data adjusted for the wheel braking coefficients associated with differing contamination types and depths. However, these contamination types and depths do not correspond to the types and depths used in TALPA/GRF based FICON or SNOTAM reports. Further, this advisory data is also based on the same maximum performance stop assumptions as the 14 CFR part 25 landing distance data, which, as we have noted, is not realistic for operational use.

In contrast, data developed for time of arrival landing distance assessment and based on AC 25-32 accounts for runway slope, non-standard temperature and pressure altitude, recommended speed additives to VREF crossing the runway threshold, a representative air distance associated with a normal flare, and reasonably expected time delays in transitioning to the stopping configuration. Most importantly, the wheel braking coefficients used to compute this data correlated directly to the reported RwyCC based on the latest industry and regulatory testing data. Finally, this data normally includes the FAA's recommended 15% safety margin.

Because EASA has incorporated a LTDA assessment requirement into their operating rules, many business aircraft manufacturers now publish "Operational Landing Distance" (OLD) performance data based on AC 25-32. While the name applied to this data will vary between manufacturers, it should be clear from the instructions and its reference to Runway Condition Codes (RwyCC, RCC, etc.) that this data is used to conduct the time of arrival landing distance assessment.

Not all manufacturers provide AC 25-32 compliant, OLD data for their airplanes. The TALPA ARC realized that some airplanes currently in use may never have this data owing either to their age or other circumstances. For this reason, they developed a generic table of landing distance factors (LDF) that are applied to the dry runway, un-factored landing distance data published in the FAA-approved AFM (Appendix II). These factors are based on the guidance in AC 25-32; however, they do take a conservative accounting of the speed at the threshold, non-standard temperature and pressure altitude, and runway slope. As a result, distances calculated using these factors will often be greater than OLD data provided by the manufacturer for a specific set of conditions. The factors in this table also include the FAA recommended 15% safety margin.

3.2.3 Time of Arrival Landing Distance Assessment

Pilots should use their version of the RCAM (Appendix I) AC 25-32 compliant OLD data or the LDF table (Appendix II), FICON NOTAMs, and pilot braking action reports to conduct a time of arrival landing distance assessment prior to top of descent. This assessment is two-fold. First, flight crews assess whether the landing distance based on the current reported RwyCC does not exceed the published LDA. Second, the flight crew determines how much the RwyCC or its corresponding braking action can deteriorate before the OLD distance required exceeds the LDA.

The process begins with obtaining the current weather conditions along with the reported RwyCC, either from the FICON NOTAM or the ATIS:

METAR KMDW 182253Z 29012G17KT 1/2SM SN BKN003 OVC007 M02/M03 A3002 RMK AO2 SLP172 T00211033

MDW RWY 31C FICON 3/3/3 60 PRCT 1/4IN WET SN AND 40 PRCT WET, 60 PRCT 1/4IN WET SN AND 40 PRCT WET, 50 PRCT 1/2IN WET SN AND 50 PRCT WET

"Midway runway three one center, condition codes three, three, three…."
After obtaining the RwyCC, the landing distance assessment begins with the flight crew determining the landing distance required using the manufacturer's OLD data. If the OLD data is not provided by the manufacturer, pilots should use the LDF table and multiply the dry runway, un-factored landing distance published in the AFM by the applicable landing distance factor for the reported RwyCC. If the landing distance required for the reported RwyCC does not exceed the runway's LDA, then after consideration of all other factors affecting a safe landing, the flight may continue.
The time of arrival landing distance assessment may be simplified if the landing field length operating rule requirements of 14 CFR part 121, 135, or 91K were applied at the time of dispatch and it was based on stopping within 60% of the published LDA. When conducting the time of arrival assessment, if the runway is dry, or if the runway is wet (RwyCC of 5) and it also has a grooved or PFC surface, the assessment for a turbojet airplane with thrust reversers or a turboprop airplane with a landing distance credit for the use of ground idle may be as simple as re-confirming that the runway in use for landing still meets the criteria used during preflight for the dispatch of the airplane under these rules. If this is confirmed, then the time of arrival landing distance assessment is considered complete if no further deterioration of the runway's condition is anticipated.

The second step in the assessment process is to determine how much the runway conditions can deteriorate before a safe landing may no longer be possible. Flight crews should determine the lowest possible RwyCC and associated pilot braking action report where the OLD distance exceeds the runway's LDA. As the flight continues towards a landing, flight crews should monitor for any new FICON reports or pilot braking action reports below the minimum required for landing. Should the RwyCC or braking action fall below the minimum required for landing, the crew should wait for improved conditions before landing or consider other alternatives, e.g., diverting to a suitable alternate airport.

The time of arrival landing distance assessment is a continuous process. It begins prior to top of descent but continues until a safe landing is completed. The RCAM, RwyCC, pilot braking action reports, and the TALPA Operational Landing Distance data are decision support tools used in making this continuous assessment.

Once the airplane has landed and exited the runway, and it is safe to do so, pilots should furnish a braking action report. These reports provide feedback to the airport operator concerning the current condition of the runway and whether additional action is required to improve its condition. Braking action reports should be made using the terms and descriptions provided in the Pilot's RCAM and must be based on the braking action provided by the wheel brakes alone. A braking action report should not be based on the stopping performance achieved using thrust reversers or other drag devices either alone or in concert with the wheel brakes.
A detailed review of TALPA and GRF is available on the NBAA's TALPA web page.

3.3. TOUCHDOWN POINT LIMIT (TPL)

14 CFR 91.175 (c) (1) states that, in order to operate below descent altitude/descent height (DA/DH) or minimum descent altitude (MDA) on an instrument approach, one of the requirements is that "The aircraft is continuously in a position from which a descent to a landing on the intended runway can be made at a normal rate of descent using normal maneuvers, and for operations conducted under part 121 or part 135 unless that descent rate will allow touchdown to occur within the touchdown zone of the runway of intended landing". The purpose of this regulation is two-fold. First, it is to ensure that the descent from the DA/DH or the MDA can be accomplished using normal maneuvers and rates of descent. Second, for part 121 and part 135 operators who primarily operate transport category airplanes, it is to ensure that these normal maneuvers and rates of descent will allow the aircraft to touchdown within the touchdown zone from the point the aircraft leaves the DA/DH or MDA. A late descent from MDA or being above glideslope or glidepath at DA/DH may preclude a touchdown within the touchdown zone, which is not permitted for these operators under this CFR and would require a missed approach even if the crew had the required runway environment in sight. Part 91 and 91K are excluded from this second requirement because there are aircraft types (e.g., light single engine airplanes), runways, and other circumstances where this requirement may not always be necessary for safety. However, for part 91/91K turbine-engine airplanes this second requirement is equally applicable to ensuring a safe landing even if not specifically required by the FARs.

The AIM's Pilot/Controller Glossary defines the touchdown zone as "The first 3,000 feet of the runway beginning at the threshold. The area is used for determination of touchdown zone elevation in the development of straight-in landing minimums for instrument approaches." ICAO defines the touchdown zone as "The portion of a runway, beyond the threshold, where it is intended landing aircraft first contact the runway." To assist in identifying the touchdown zone, runways with at least one precision approach procedure (ILS) will be marked with touchdown zone markings. For runways approximately 8,000' or greater, these markings will extend 3,000' from the threshold. With a runway of approximately 5,000', the touchdown zone markings extend only 1,500' from the threshold. An aiming point marking is positioned 1,000' from the threshold; however, this may vary depending on VGSI siting requirements, etc. At night, the touchdown zone lighting extends the full 3,000' from the runway threshold. These markings aid the pilot during the transition from instrument meteorological conditions (IMC) to visual conditions when continuing the approach from DA/DH or descending from the MDA.

While 14 CFR 91.175 (c) (1) establishes the requirements to leave DA/DH or MDA, it is still important that the pilot conduct the descent in a manner that allows a touchdown within the touchdown zone. Remaining on the glideslope/glidepath or the VGSI path aids the pilot in doing so. Pilots must avoid the temptation to dip below glideslope/glidepath as this could result in striking obstacles during the visual descent or could result in main gear touchdown before the threshold. "Dipping below" does not decrease landing distance and may actually increase landing distance because the flare becomes shallower resulting in less airspeed dissipation prior to touchdown. This is confirmed by the FAA's requirement for Part 25 certification (detailed in AC 25-7D) to assess landing distance using approach angles as low as 2.5 degrees to determine a worst case scenario.

For turbine-engine, transport or commuter category airplanes, the airplane's touchdown should occur not later than the end of the touchdown zone, or 3,000' from the end of the runway threshold, whichever is less. Otherwise, a go-around and missed approach should be accomplished. However, on a shorter runway where the full 3,000' touchdown zone is not available, or where runway contamination significantly impacts stopping performance, the question may be asked: how far down the runway can the airplane touchdown before it may no longer be able to stop on the remaining runway?

Recall that the TALPA operational landing distance (OLD) data provides the pilot with the runway stopping distance for the reported runway condition code or braking action. Unless actual flight test data is used and provides a shorter air distance, this operational landing data usually includes an allowance for 1,500 feet or 7 seconds of air distance from the threshold to touchdown. Assuming a 1,500' air distance, we can calculate a touchdown point limit (TPL). Here's an example:

- Reported runway condition code is "3"
- OLD landing distance for an RwyCC of "3" = 4,000'. This includes a safety margin (typically 15%).
- Runway's landing distance available (LDA) = 5,000'
- Assumed air distance = 1,500' (unless the manufacturer specifies otherwise)
- Touchdown point limit (TPL) =
  - LDA – OLD distance (5,000' – 4,000') = 1,000' excess runway available
  - Air distance (1,500') plus excess available runway (1,000') =
  - 2,500' from the runway threshold

If the touchdown occurs prior to 2,500' from the threshold and the requisite stopping devices (e.g., thrust reversers, spoilers, and braking level) upon which the OLD data is predicated on are used, the airplane should be able to safely stop before the end of the runway. While a touchdown more than 2,500' beyond the threshold meets the FAR requirement to continue the visual descent below the DA/DH or MDA, doing so might be unsafe based on the runway's condition. If the touchdown does not occur prior to the 2,500′ point beyond the runway threshold, a go around and missed approach should be accomplished.

A go around initiated close to the ground will likely result in main wheel touchdown even after the go around is initiated as the aircraft transitions from descending to climbing. Crews should not abort a go-around once it has begun, even if main wheel contact occurs, and for this reason, should be very diligent about not raising the landing gear until a positive rate of climb is established.

3.4. COMMITTED TO STOP POINT

Is there ever a situation where a runway overrun is actually the best (or least worst) remaining option?

On July 31, 2008, a Hawker 800 crew attempted to go around after a landing attempt at KOWA had gone awry, but the go-around was not attempted until 17 seconds after touchdown. The aircraft struck obstacles beyond the departure end of the runway and crashed. All aboard perished. The NTSB report concluded that the crew would have been better off continuing off the end of the runway: "…at the time that the go-around was initiated, the deceleration rate was such that the airplane would have exited the runway end at a ground speed of between 23 and 37 knots and stopped between 100 and 300 feet into the 1,000-foot-long runway safety area."

In response to this accident, the FAA issued InFO 17009 to describe the concept of a committed-to-stop point during landing. While short on verbiage, it recommends that operators develop, as part of their SOPs, a point at which a go-around is no longer possible, and the crew is committed to stopping the airplane. Because the list of variables affecting the determination of such a point is so extensive and could easily vary from one landing to the next, even on the same aircraft operated by the same crew, the FAA provides suggestions for conditions, speeds, or runway distance remaining as the determining factor for where the crew becomes committed to stop. A more in-depth article on this topic was published by the Flight Safety Foundation and can be accessed here.

SECTION 4

Training

4.1. TAKEOFF SCENARIOS

4.1.1 Takeoff go/no-go decision-making

If you put 10 pilots in a room, gave them a list of possible CAS messages and other system anomalies they might see during the takeoff roll, and asked them whether they would abort or continue for each one, you would not only get varied answers from each pilot, but you would spend considerably more time than what's available to make that decision in the actual airplane should such a scenario occur. More importantly, as previously discussed, getting that decision wrong can have grave consequences.

Using data from the FAA's Pilot Guide to Takeoff Safety, some Part 142 training providers have developed enhanced training courses that explore the takeoff decision-making process in a classroom setting in order to remove the complicated analysis historically required to make the proper go/no-go decision during the takeoff roll. Once this discussion is complete, pilots can then apply the lessons learned in the controlled environment of a simulator. This practice serves to retrain the pilot's brain to brief the upcoming takeoff as either being go-oriented or stop-oriented based on a number of factors present at the time. By doing so, pilots become adept at reacting in a binary way (go or stop) to any abnormal stimuli that occur during the takeoff roll, thus removing the ambiguity created by trying to analyze all of those factors in a split-second decision during the high-speed portion of the takeoff roll.

Because this training is not currently required by the FAA to meet the recurrent training requirements of Parts 61 or 135, training providers do not include it in their normal curriculum but offer it as an add-on. However, a department committed to giving its pilots all of the tools available to mitigate the risks of runway excursions on takeoff will find this additional training to be fundamentally transformative in the way they approach takeoff briefings and execution.

4.1.2 Other takeoff scenarios

According to the FAA's Pilot Guide to Takeoff Safety, 76% of all rejected takeoffs (RTOs) are initiated at 80 knots or less and rarely result in an accident. At the other end of the data, only 2% of RTOs occur at or beyond 120 knots (another 4% occur between 100 and 120 knots), but this is where we find the majority of runway overruns.

Most training scenarios involve one of two outcomes: 1) An anomaly is experienced just after the takeoff roll is initiated and the crew aborts at low speed, or 2) an engine failure occurs at V_1 and the crew continues the takeoff to become airborne. But, what about the mechanical failure or red CAS message that occurs at high speed but before V_1? Since high-speed RTOs are the most likely to result in a runway overrun, it stands to reason that we should be practicing this in the simulator. Since your training provider has to check the RTO box anyway, a pilot or operator could request that the anomaly leading to the abort not occur until just prior to V_1, thus allowing the crew to experience the challenge of performing a high-speed RTO.

While on the subject of RTOs, there are other challenging aspects that could also be practiced in the safety of a simulator. For example, request that your training provider make the runway contaminated in order for the crew to fully appreciate the degradation of braking and steering during an aborted takeoff. By doing so, crews will pay greater attention to takeoff planning when the surface is covered in frozen contaminants.

Even on dry runways, directional control during an RTO can be difficult in a strong crosswind. Add in an engine failure prior to V1 on the side from which the wind is blowing to really put the pilot's skills to the test. And for the ultimate challenge, request that the runway is the minimum width allowed by the operator, making the margin for lateral error that much less.

Finally, if the OEM provides data for more than one takeoff flap setting, crews can be trained to evaluate the greater safety margin afforded by a higher flap setting (climb performance permitting) and practice both aborting at or before the lower V_1 and getting airborne with another notch of flaps to retract if it's not a standard practice in line flying.

By presenting flight crews with these scenarios in training, they will be able to hone their skills, have a greater appreciation for these conditions during takeoff performance planning, and put greater emphasis on being prepared for an RTO on every takeoff.

4.2. LANDING SCENARIOS

4.2.1 Stabilized approach/go-around compliance

As discussed at great length throughout this guide, failure to put the aircraft on a stabilized approach prior to landing, coupled with the failure to initiate a go-around when stabilized approach criteria are not met, is the most common scenario leading to a runway excursion – typically in the form of an overrun.

Attaining consistent adherence to a stabilized approach policy requires more than just publishing the policy and hoping for the best. Assuming the policy has been crafted in a manner that will invite maximum buy-in from the pilot group (as discussed in section 1.3), then the final phase of obtaining compliance is training the pilots about the risks of continuing an unstable approach by citing the data referred to in this guide. An effective training program will highlight the prevalence of runway excursions that occur following an unstable approach that did not result in a go-around. It should also make clear to pilots that the company has adopted a "no fault go-around policy", and that any questions from passengers about the need for, or inconvenience resulting from, a go-around should be referred to flight department management for clarification. Finally, the training program should also include honest discussions about some of the psychological factors discussed in section one in order to demystify and destigmatize any long-held attitudes towards saving a bad approach instead of going around.

In keeping with the adage to "train like you fly, and fly like you train," department management should create a clear expectation that a stabilized approach should be flown during all initial and recurrent simulator training events, and that failure to do so should result in a go-around, just as if the crew is flying the real airplane.

4.2.2 Contaminated runway/anti-skid brakes

As previously referenced, contaminated runway surfaces are the second leading cause of runway excursions during landing. The Beechjet crew at MAC discovered that even standing water on a non-porous, non-grooved runway could create contamination that contributes to a runway overrun. Despite these facts, landing on contaminated surfaces is not required by Parts 61 or 135 for initial or recurrent training and is therefore not a part of most Part 142 training curricula.

The objective of adding a request to land on a contaminated surface during a simulator session is not to get crews comfortable with the concept or to become proficient at it, but to provide experiential knowledge of how the aircraft will perform in these conditions so that they have a better understanding of what to expect and can make a more informed decision on whether or not to proceed with the approach and landing.

In addition, a simulated landing on a contaminated surface provides an opportunity for crews to apply enough brake pressure for the anti-skid system (if installed) to activate. By doing so, crews will also be able to feel the pulsating braking action that results so that, should this situation occur in the airplane, they will not be surprised by it or think that something is wrong with the brakes.

SECTION 5

Safety Management and Flight Data Monitoring

5.1. SAFETY MANAGEMENT SYSTEMS

The concept of employing a safety management system (SMS) evolved from legal developments in the 19th and 20th centuries aimed at improving working conditions as the industrial revolution transformed the workplace. At its core, SMS is a methodical approach to identifying hazards and risks in the working environment, developing countermeasures to mitigate those hazards/risks, and evaluating the effectiveness of the countermeasures after a pre-determined period of time has elapsed since their implementation. SMS is not unique to aviation, but since its adoption over the last three decades, it has had a transformative effect on the way all sectors of aviation approach safety.

The FAA mandated that Part 121 air carriers implement SMS by 2018. As of this writing, that mandate is set to expand to include all Part 135 operators, air tour operators under 91.147, and type certificate holders under Part 21. Part 91 operators are exempt from this mandate, but the International Business Aviation Council and its signatories—including NBAA—have long endorsed the value of implementing SMS.

A properly functioning SMS, with buy-in from all participants, is able to identify risks associated with all facets of an aviation organization, including the ability to assess potential or actual risks associated with the policies and procedures governing takeoff and landing practices. It provides the frontline employee a path to communicate concerns or report close calls—anonymously, if needed, and in a non-punitive environment—which can then be objectively evaluated and acted upon as deemed necessary. The inclusion of all employees in the SMS drastically broadens the scope of perspectives and the breadth of operating experiences to create a far more holistic view of how the organization is operating. It is another highly effective tool to combat the chance of having a runway excursion and comes with the added bonus of mitigating other risks in the aviation organization as well.

5.2. FLIGHT DATA MONITORING

Work-as-imagined is often described as the description of how tasks are to be completed in manuals, checklists, policies, and procedures. Work-as-done is described as how that same work is actually being performed by frontline employees. Do the two coincide 100%? Well, when it comes to the actual operation of the aircraft, there is a way to gain better insight into this question.

Modern jet aircraft record nearly every parameter of how the aircraft is being operated on the flight data recorder. This data can be accessed through various means, uploaded to a third-party data analysis provider, and analyzed. A properly functioning flight data monitoring program (sometimes referred to as Flight Operations Quality Assurance (FOQA), an FAA-approved program) will maintain anonymity of the crews operating each flight and focus more on overall trends in the data, rather than finding specific faults on any particular flight. By doing so, an operator can gain invaluable knowledge on how well work-as-done coincides with work-as-imagined.

Compliance with all manner of runway performance-related activities (stabilized approach and go-around policies, touchdown points, flare distances, rates of rotation, etc.) can easily be gleaned from this dataset. Additionally, it can be compared to other participating operators flying similar aircraft, thus benchmarking your operation against the broader fleet. If, upon further analysis, it appears that compliance is not as consistent as imagined, this can be addressed with flight crews through sharing of the data, conversations about expectations and training, as needed.

Flight data monitoring and analysis is yet another tool, one that is rapidly improving and seeing vastly wider adoption, that enables a business aviation operator to have true insight into how its aircraft are being operated, allowing negative trends to be mitigated before they become a runway excursion or other accident.

CONCLUSION

In 2022 alone, there were some 31 million airline flights operated worldwide. According to Flight Safety Foundation data, of those 31 million flights, only 16 resulted in a runway excursion. Business aviation had a similar number of runway excursions (17), but that was out of a far smaller number of total operations.

Runway excursions cause serious and sometimes fatal injuries, substantially damage or destroy airplanes, lead to time-consuming and costly litigation, negatively impact the image and reputation of the owner/operator and invite more regulatory scrutiny. Furthermore, if a pilot survives the excursion, they can expect to find future employment far more difficult with such an accident on their record.

As a segment of professional aviation, business aviation can and must do better.

Improvement begins with knowledge of the risks and how to mitigate them. There already exists a wealth of knowledge and data, compiled by some of the most respected organizations and regulators in the world. It is incumbent upon all business aviation operators to become familiar with this material, incorporate it into their SOPs as appropriate, and contribute to reducing the frequency of runway excursions in the sector. NBAA has published this guide in an attempt to bring this information to light and provide references to the expertly compiled data for those who wish to explore it.

References

FAA:

- Advisory Circular 25-7D
- Advisory Circular 120-82
- Advisory Circular 91-79B
- InFO 17009
- Pilot Guide to Takeoff Safety

Flight Safety Foundation:

- 2022 Safety Report
- Approach and Landing Accident Reduction
- ALAR Toolkit
- Global Action Plan for the Prevention of Runway Excursions
- Go-Around Decision-Making and Execution Project
- Reducing the Risk of Runway Excursions

APPENDIX I—PILOT/OPERATOR RCAM

Table 3-2. Pilot/Operator Runway Condition Assessment Matrix (RCAM)

Assessment Criteria		**Control/Braking Assessment Criteria**	
Runway Condition Description	RwyCC	**Deceleration or Directional Control Observation**	Reported Braking Action
• Dry	6	----	---
• Frost • Wet (includes damp and 1/8 inch depth or less of water) **1/8 inch (3mm) Depth or Less of:** • Slush • Dry Snow • Wet Snow	5	Braking deceleration is normal for the wheel braking effort applied AND directional control is normal.	Good
-15 °C and Colder Outside Air Temperature: • Compacted snow	4	Braking deceleration OR directional control is between Good and Medium.	Good to Medium
• Slippery When Wet (wet runway) • Dry Snow or Wet Snow (any depth) over Compacted Snow **Greater Than 1/8 inch (3mm) Depth of:** • Dry Snow • Wet Snow **Warmer Than -15 °C Outside Air Temperature:** • Compacted Snow	3	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced.	Medium
Greater Than 1/8 inch (3mm) Depth of: • Water • Slush	2	Braking deceleration OR directional control is between Medium andPoor.	Medium to Poor
• Ice	1	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantlyreduced.	Poor
• Wet Ice • Slush Over Ice • Water Over Compacted Snow • Dry Snow or Wet Snow over Ice	0	Braking deceleration is minimal to nonexistent for the wheel braking effort applied OR directional control is uncertain.	Nil

APPENDIX II—LANDING DISTANCE FACTORS TABLE, AC 91-79B

The following factors are multipliers to the unfactored AFM demonstrated landing distances:

Runway Condition Code	6	5 Grooved/ PFC Good	5 Smooth	4	3	2	1
Braking Action	Dry	Good	Good	Good to Medium	Medium	Medium to Poor	Poor
Turbojet, No Reverse	1.67	2.3	2.6	2.8	3.2	4.0	5.1
Turbojet, with Reverse	1.67	1.92	2.2	2.3	2.5	2.9	3.4
Turboprop (see Note)	1.67	1.92	2.0	2.2	2.4	2.7	2.9
Reciprocating	1.67	2.3	2.6	2.8	3.2	4.0	5.1

These LDFs apply only to turboprops when the AFM provides for a landing distance credit for the use of ground idle power lever position if advisory data for a landing distance assessment at TOA is not available from the manufacturer or from a performance data provider. Turboprops without this credit should use the "Turbojet, No Reverse" LDFs.

NBAA
National Business Aviation Association
1200 G Street NW, Suite 1100
Washington, DC 20005
www.nbaa.org
(202) 783-9250 | info@nbaa.org

November 2023

ABOUT NBAA

Founded in 1947 and based in Washington, DC, the National Business Aviation Association (NBAA) is the leading organization for companies that rely on general aviation aircraft to help make their businesses more efficient, productive and successful. Contact NBAA at 800-FYI-NBAA or info@nbaa.org. Not a member? Join today by visiting **nbaa.org/join**.

ACKNOWLEDGMENTS

This resource was originally prepared by the NBAA Safety Committee in 2016 and updated by the NBAA Domestic Operations Committee in 2023. This resource is general in nature and is not intended as legal advice with respect to any particular flight operation. Review NBAA's runway safety resources at nbaa.org/runway-safety.