Transportation Safety Board of Canada

Bureau de la sécurité des transports du Canada

AVIATION INVESTIGATION REPORT
A11O0098

RUNWAY EXCURSION

SKYCHARTER LTD.
DASSAULT FALCON 10 C-GRIS
TORONTO/BUTTONVILLE MUNICIPAL AIRPORT, ONTARIO
17 JUNE 2011

Canada

Aviation Investigation Report

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Skycharter Ltd.
Dassault Falcon 10 C-GRIS
Toronto/Buttonville Municipal Airport, Ontario
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Report Number A11O0098

Synopsis

The Skycharter Ltd. Dassault Falcon 10 (registration C-GRIS, serial number 002) was on a flight from Toronto-Lester B. Pearson International Airport to Toronto/Buttonville Municipal Airport, Ontario, with 2 pilots on board. Air traffic control cleared the aircraft for a contact approach to Runway 33. During the left turn on to final, the aircraft overshot the runway centreline. The pilot then compensated with a tight turn to the right to line up with the runway heading and touched down just beyond the threshold markings. Immediately after touchdown, the aircraft exited the runway to the right, and continued through the infield and the adjacent taxiway Bravo, striking a runway/taxiway identification sign, but avoiding aircraft that were parked on the apron. The aircraft came to a stop on the infield before Runway 21/03. The aircraft remained upright, and the landing gear did not collapse. The aircraft sustained substantial damage. There was no fire, and the flight crew was not injured. The Toronto/Buttonville tower controller observed the event as it progressed and immediately called for emergency vehicles from the nearby municipality. The accident occurred at 1506 Eastern Daylight Time.

Ce rapport est également disponible en français.

Factual Information

History of the Flight

At approximately 1500, [1] the aircraft departed Runway 05 at Toronto-Lester B. Pearson International Airport (CYYZ). The flight crew completed the after-take-off checklist and began the climb to a cleared altitude of 5000 feet above sea level (asl).

At 1500:56, as the aircraft climbed through 3400 feet asl, the Toronto departure air traffic controller re-cleared the aircraft to maintain 4000 feet asl.

At 1501:20, the first officer (FO) and pilot not flying (PNF), who was in the right seat, switched from the Toronto departure control frequency to the Toronto/Buttonville Municipal Airport (CYKZ) automatic terminal information service (ATIS) frequency to obtain the latest airport and weather information. The captain and pilot flying (PF), who was in the left seat, monitored the Toronto departure control frequency on the other radio.

At 1501:42, while the aircraft was level at 4000 feet asl and flying at a ground speed of 270 knots, [2] the Toronto departure air traffic controller cleared the aircraft to descend to 3000 feet asl and fly directly to CYKZ. Over the next 30 seconds, the captain made 4 attempts to read back the clearance. However, the Toronto departure air traffic controller did not receive the transmissions. At this time, the captain requested that the FO acknowledge the clearance on the other radio. As the aircraft began to descend, the ground speed reached 290 knots.

At 1502:34, the aircraft was descending through 3400 feet asl [3] with a ground speed of 280 knots and was 6 nautical miles (nm) west of CYKZ. The FO switched radio frequencies back to Toronto departure and read back the clearance.

At 1502:53, the Toronto departure air traffic controller instructed the aircraft to switch frequencies to the Toronto area control centre (ACC). When radio contact was established, the Toronto ACC controller cleared the aircraft to descend to 2400 feet asl and to expect a contact or visual approach to Runway 33 at CYKZ.

At 1503:25, the Toronto ACC controller cleared the aircraft for a contact approach to Runway 33, to begin the descent, and to keep the approach tight, as there was traffic to follow. At that point, the aircraft was approximately 3 nm from the airport, descending through 2600 feet asl with a ground speed of 230 knots, and heading towards the threshold of Runway 33 on a tight left base.

At 1503:40, 1.6 nm from the threshold, with a ground speed of 220 knots and descending through 1900 feet asl, the aircraft turned right to widen the left base (Figure 1).

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1 All times are Eastern Daylight Time (Coordinated Universal Time minus 4 hours).

2 Ground speeds were obtained from radar data. Indicated airspeed, which is displayed in the cockpit, was slightly lower than the ground speed.

3 All altitudes and distances are based on radar data.

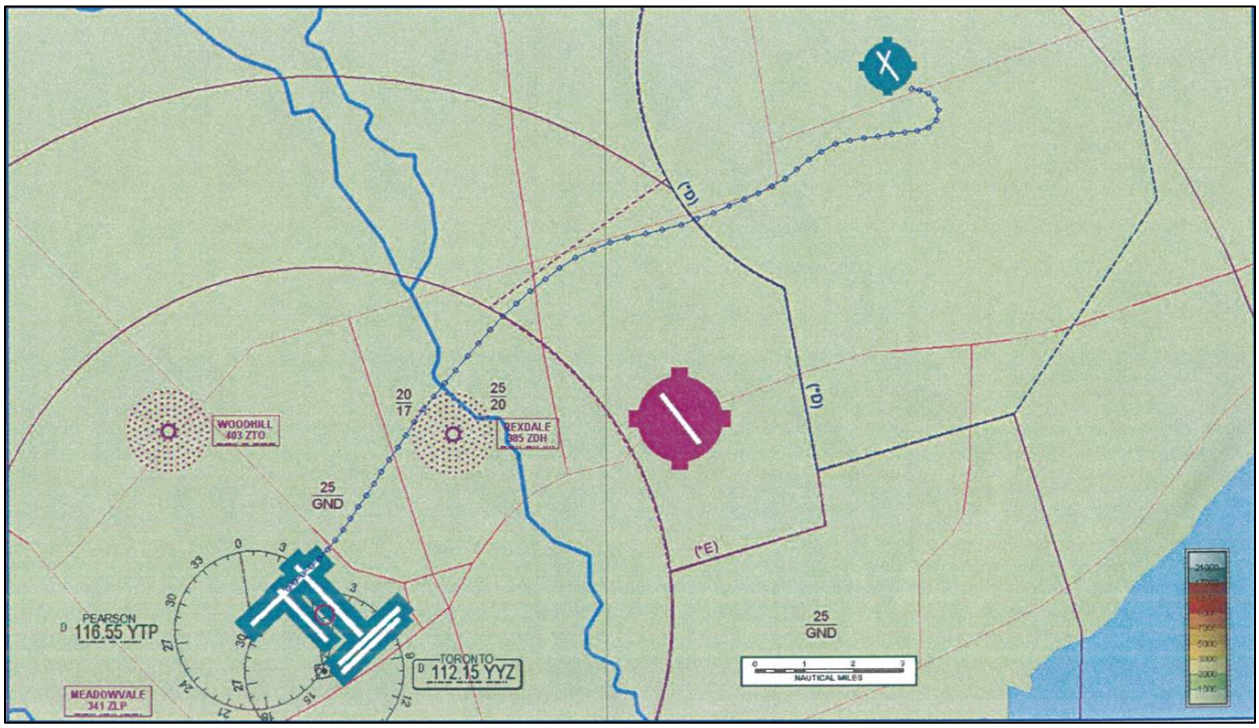

Figure 1. Radar plot of aircraft flight path

At 1503:53, the Toronto ACC controller instructed the aircraft to switch to the CYKZ tower frequency. The captain commanded flaps, and the FO read back the Toronto ACC controller's request. The FO contacted the CYKZ tower controller with the flight identification and position on left base for Runway 33. The CYKZ tower controller provided altimeter information and cleared the aircraft to land on Runway 33. At this time, the aircraft was descending through 1400 feet asl with a ground speed of 210 knots, and was located approximately 0.3 nm from the inbound track to Runway 33. The aircraft leveled out from the right turn and was heading in an eastward direction. It flew through the inbound track at a transverse angle of about 120° at approximately 1 nm final. In an attempt to regain the runway centreline, the aircraft banked left, exceeding 30° of bank. The aircraft overflew the runway centreline by approximately 0.3 nm.

At 1504:20, the ground proximity warning system (GPWS) issued an aural alert to pull up. A missed approach was called by the FO in a low tone of voice and using non-standard phraseology. The captain responded, but continued the approach. Shortly afterwards, the GPWS sounded another aural alert to pull up.

At 1504:29, the aircraft was approximately 300 feet above ground level (agl), 0.7 nm south of Runway 33 and 0.3 nm east of the inbound track, in a left bank towards the runway threshold. The captain called for full flaps and banked the aircraft steeply to the right after regaining the runway centreline while on short final.

At 1504:35, the GPWS called out 200 feet. The FO reminded the captain of the landing reference speed (Vref), [4] and twice called out Vref plus 5 knots.

At 1504:46, the GPWS called out 100 feet. The FO notified the captain of full flap extension.

At 1504:48, the GPWS called out 40 feet. Less than 1 second later, the FO called out for more engine power.

At 1504:49, the aircraft touched down hard on the main landing gear in a nose-high attitude, then immediately departed the runway surface to the right. The ground speed during the runway excursion could not be determined, but was estimated to be less than 110 knots. The captain applied the brakes and initially attempted to steer the aircraft onto the runway using the rudder. However, due to the infield's grass surface, braking and steering responses were minimal. Although the tiller was available for nose-wheel steering, it is not normally used until the speed is below 80 knots.

The aircraft traversed the grass infield to the intersection of taxiways Charlie and Bravo, continued onto taxiway Bravo, and struck a runway/taxiway identification sign before crossing the intersection of taxiways Bravo and Alpha. The aircraft struck the sign with the right side of the nose section, the inboard leading edge and the right-wing slats. The sign was struck with sufficient force that it was torn away from its base and came to rest behind the aircraft on the apron. The aircraft came to a stop on the grass just beyond the intersection of taxiways Bravo and Bravo/Alpha.

The CYKZ tower controller observed the aircraft departing the runway and immediately activated the emergency call, alerting the local municipality emergency response units. The pilots secured the aircraft by shutting down the electrical power and both engines. The pilots then exited the aircraft through the main cabin door. From the application of take-off power from Runway 05 at CYYZ, to engine shut down after the aircraft came to a stop off Bravo taxiway in the adjacent grass infield, the flight duration was approximately 6 minutes.

Flight Crew Information

Records indicate the crew was certified and qualified for the flight in accordance with current regulations. Both pilots held a valid airline transport pilot licence. They received recurrent Falcon 10 training in January 2011. The training records indicated they had been trained in crew resource management (CRM) as a part of the flight simulator training.

The captain had approximately 12 000 hours total flying time with 4000 hours on Falcon 10. The FO had 7100 hours total flying time with 475 hours on Falcon 10. The pilots were off-duty for approximately 60 hours prior to the occurrence and were well rested. There was no indication that their performance was degraded by physiological factors. Both pilots only flew this aircraft for Skycharter and were always paired as a flight crew. They were knowledgeable about the

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[4] Vref is the landing reference speed (typically 1.6 times the stall speed), based on the aircraft's weight and configuration.

operational procedures and duties within the cockpit environment. The crew did not routinely fly this route or other short routes.

The chart below illustrates the nature of charter flying, which is on an as-needed basis. Flying times are limited, and because flight crews are always to be ready to fly company charters, company policy does not allow for any additional flying with other operators.

Flight crew member	Hours last 30 days	Hours last 60 days	Hours last 90 days
Captain	10	25.2	28.0
First officer	10	25.2	28.0

Crew Resource Management

CRM, originally known as cockpit resource management, was developed around 1979 at a NASA workshop when it was recognized that human error was contributing to aircraft accidents. CRM focuses on interpersonal communication, leadership, and decision making. During CRM training, flight crews learn through participation in different scenarios that may be encountered during flight and that could potentially affect safety. CRM trains flight crew members to develop communication skills so that when an unsafe event is recognized by any crew member, it is communicated in a manner that raises the attention of the pilot-in-command. This will in turn generate a response and acknowledgement from the pilot-in-command and other crew members. CRM, to a certain extent, is implemented in the company's standard operating procedures (SOPs) with an action-and-response type of approach to different callouts, depending on the phase of the flight.

Skycharter Standard Operating Procedures

The Skycharter SOP states that flight crews must use the Falcon 10 checklist for all flights. The Falcon 10 checklist provides flight crews with a step-by-step method of verifying and preparing aircraft systems for all phases of flight.

The checklist must be used following a challenge and response method with pre-determined phraseology. If the captain does not call for the checklist in a timely fashion, the FO should initiate. No deviation from these procedures is acceptable unless the captain determines that the safety of flight may be compromised.

During the occurrence flight, the flight crew used the checklist up to the after-take-off phase. The cruise, pre-descent, approach, and landing segments of the checklist were not performed by either crew member.

According to the SOP, prior to all approaches, the PF shall give an approach briefing which includes the type of approach, runway, navigational aids, approach altitudes, and missed approach point. There are standard calls for deviations to airspeed, altitude, localizer, glide slope and angle of bank greater than 30°. No callouts to such deviations occurred on this flight.

Skycharter's SOP states that the aircraft must meet the approach window criteria within 500 feet above touchdown. If not, a missed approach must be executed.

The Skycharter approach window criteria are as follows:

- within 1 dot deflection of the localizer and glide slope;
- vertical speed less than 1000 feet per minute;
- indicated airspeed within plus or minus 10 knots of the approach speed (Vapp), but not less than Vref;
- no flight instruments flags with the landing runway or visual references not in sight;
- landing configuration except for full flaps (non-precision or single-engine approaches).

The phraseology stated in the SOP for a missed approach is "Missed Approach". The SOP does not include a procedure to follow if a GPWS alert is issued.

According to the SOP, the airspeed for a visual flight rules (VFR) pattern should be 160 knots on the downwind leg of the circuit, 140 knots on the base leg and Vref plus 10 knots on the final approach. Prior to take-off on the occurrence flight, the crew determined that Vref was 117 knots for the calculated landing weight of 17 000 pounds. The aircraft was cleared to fly directly to CYKZ and joined the circuit on base leg. At this point, the aircraft's calibrated airspeed was 186 knots.

Canadian Aviation Regulations

According to subsection 602.32(1) of the *Canadian Aviation Regulations* (CARs):

> No person shall
> *(a)* operate an aircraft at an indicated airspeed of more than 250 knots if the aircraft is below 10,000 feet ASL; or
> *(b)* operate an aircraft at an indicated airspeed of more than 200 knots if the aircraft is below 3,000 feet AGL, within 10 nautical miles of a controlled aerodrome unless authorized to do so in an air traffic control clearance.

Stabilized Approach Criteria

The Flight Safety Foundation (FSF) Approach and Landing Accident Reduction (ALAR) Task Force studied 76 approach-and-landing accidents and serious incidents from 1984 to 1997 and found that unstabilized approaches were a causal factor in 66% of these occurrences.

The task force found that high-energy approaches (i.e., high and fast) resulted in loss of aircraft control, runway overruns, and runway excursions. The task force also found that flight-handling difficulties, for example when the crew is unable to control the aircraft to desired flight parameters such as airspeed, altitude, and rate of descent, were a causal factor in 45% of the approach-and-landing accidents and serious incidents.

An approach is stabilized only if all the criteria in the company SOP are met before or when the aircraft reaches the applicable minimum stabilization height. An approach that becomes unstabilized below 1000 feet agl in instrument meteorological conditions (IMC), or below 500 feet above airport elevation in visual meteorological conditions (VMC), requires an immediate go-around (Appendix A).

In this occurrence, there were several indicators of an unstabilized approach. These included excessive bank angle, activation of the GPWS, late extension of flaps, excessive flight-parameter deviations when crossing the minimum stabilization height, and deviation down to the runway threshold.

Runway Excursion

The main landing gear tire marks indicated the aircraft touched down on the left main landing gear first, followed by the right main landing gear 24 feet further. It was calculated that the aircraft exited the runway at an angle of 37° to the right of the runway centreline, or on a magnetic heading of 007°. Tire marks also indicated that the aircraft was already positioned at this angle when it touched down, and that, shortly after touchdown, brakes were applied with sufficient force to activate the anti-skid system (Appendix B).

Aircraft Damage

The slats were extended for the landing and were substantially damaged by the impact with the sign. The right wing tip was also damaged from ground contact as the aircraft travelled through the infield.

Although the damage appeared to be limited to the nose section, right wing and slats, subsequent inspections carried out after the aircraft was removed from the infield revealed substantial damage to the nose landing gear strut and support frame.

In addition, after internal inspections on both the engines, it was found that they had ingested dirt and grass, rendering them unserviceable.

Aircraft Information

Records indicate that the aircraft was serviceable for the flight and that there were no outstanding maintenance defects. The aircraft had a total time in service of 12 697 hours. It had been in continuous service with the operator for approximately 20 years. The aircraft was maintained in accordance with current regulations and an approved maintenance program.

To assist in maintaining directional control and prevent wheel lockup after touchdown, the aircraft was equipped with an anti-skid assisted brake system, but was not equipped with engine thrust reversers. On this aircraft, the air brakes are selected by the flight crew to extend after touchdown, which reduces ground speed by increasing drag. During the landing and after touchdown, the air brakes were not extended, contrary to the *Airplane Flight Manual* landing procedures.

The aircraft was equipped with a cockpit voice recorder (CVR) which was removed from the aircraft and downloaded at the TSB Engineering Laboratory. The aircraft was not equipped with a flight data recorder (FDR), nor was one required by regulation.

Terrain Awareness and Avoidance Warning System

The aircraft was equipped with a Sandel ST 3400 Class B [5] terrain awareness and avoidance warning system (TAWS). [6] The TAWS issues GPWS alerts to the flight crew which include aural and visual indications of possible inadvertent flight into terrain. Based on an aircraft's radar altitude and phase of flight, GPWS alerts are generated when the following are unsafe:

- vertical speed
- rate of closure to terrain
- accumulated altitude loss
- airspeed, flap and gear configuration
- glideslope deviation

The FSF recommends the following GPWS procedures by all flight operations:

- When a GPWS warning occurs, pilots should immediately, and without hesitating to evaluate the warning, execute the pull-up action recommended in the company procedure manual;
- In the absence of a company procedure, an immediate maximum performance full-power climb should be initiated and continued until the GPWS warning stops and the crew determines that terrain clearance is assured;
- This immediate pull-up procedure should be followed except in clear daylight visual meteorological conditions when the flight crew can immediately and unequivocally confirm a false GPWS warning; and,

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5 A Class B TAWS includes Mode 1: excessive rate of descent with respect to terrain and Mode 3: negative climb rate or altitude loss before acquiring 700 feet terrain clearance after take-off or missed approach. A Class B TAWS also includes forward looking terrain avoidance (FLTA) and premature descent algorithm (PDA) which alerts if the aircraft is hazardously below the normal approach path to the nearest runway.

6 A TSO C151b TAWS is composed of two parts - the GPWS and the FLTA.

- Air traffic control (ATC) should be notified as soon as possible after a GPWS warning or pull-up. [7]

Weather and Airport Information

The 1500 aviation routine weather report (METAR) for CYKZ indicated the wind 220° true at 2 knots, visibility 10 statute miles (sm), cloud cover few at 2900 feet, broken cloud at 5100 feet, temperature 22°C, dew point 17°C, altimeter setting 29.84 inches of mercury.

The upper winds forecast at 3000 feet indicated a 1 knot headwind for the occurrence flight.

CYKZ is a controlled airport with an elevation of 650 feet and 2 asphalt runways. Runway 15/33 is 3897 feet in length and 100 feet in width. Runway 03/21 is 2694 feet in length and 80 feet in width. Runway 15/33 has maintenance and aircraft storage hangars located adjacent to taxiway Bravo on the right side and taxiway Charlie on the left side. A ramp for parked aircraft exists to the right of taxiway Bravo, before the Bravo/Alpha taxiway.

The following TSB Engineering Laboratory report was completed:

- LP067/2011 – CVR Download

Analysis

The investigation determined that the aircraft was serviceable and that there were no maintenance defects that affected the aircraft during the flight. Also, crew fatigue and weather conditions did not contribute to this occurrence. Therefore, the investigation focused on the manner in which the aircraft was flown prior to touchdown on Runway 33, and the procedures followed by the crew in this occurrence.

Considering the entire flight was approximately 6 minutes in duration and below 4000 feet asl, there was no need to fly at the speeds attained during the flight. Although radar indications provided ground speed values, it was determined that, even after the conversions to indicated airspeed values, the aircraft was flown in excess of the current regulations and Skycharter's SOP.

The excessive speed, and the fact that the crew did not routinely fly this route or other short routes, reduced the amount of time available to perform all the tasks dictated by the company SOP, the required checklist items and the approach briefing. This resulted in the crew flying an unstabilized approach.

ATC requested that the flight crew keep the circuit tight. Because of its excessive speed, however, the aircraft overshot the final approach track. The radar display indicated that the

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[7] Flight Safety Foundation, *Safety Alert,* www.faa.gov/training_testing/training/media/cfit/volume2/pdf/pages/page5_09.pdf (last accessed on September 28 2012).

aircraft transitioned through the final approach course at approximately 140 knots. Consequently, a left turn was performed exceeding 30° of bank, well above the SOP limit and outside the FSF criteria for a stabilized approach. The distance to the runway threshold continued to reduce quickly, and manoeuvres to regain runway heading became more aggressive and non-standard.

The FO called for a missed approach using non-standard wording. The GPWS aural alert sounded twice. Either of these should have prompted the captain to perform a missed approach. The non-standard wording and the tone used by the FO were insufficient to deter the captain from continuing the approach. The captain's commitment to landing or lack of understanding of the degree of instability of the flight path likely influenced the decision not to conduct a missed approach.

Full flaps were called for by the captain on final approach and subsequently selected by the FO. The flaps reached full extension approximately 13 seconds afterwards, when the aircraft was about 40 feet above the runway.

Just prior to touchdown, the FO called for engine power, likely to arrest the high rate of descent. The captain did not increase engine power, and the aircraft touched down hard. Attempts at rudder steering and braking were ineffective in reducing speed and providing directional control, as tire traction would have been greatly reduced on the grass surface.

As the aircraft exited the infield and entered the paved taxiway Bravo, the brakes regained effectiveness. However, directional control was not fully regained, and the aircraft struck the runway/taxiway identification sign before exiting Bravo taxiway onto the grass infield.

Findings as to Causes and Contributing Factors

1. The crew flew an unstabilized approach with excessive airspeed.

2. The lack of adherence to company standard operating procedures and crew resource management, as well as the non-completion of checklist items by the flight crew contributed to the occurrence.

3. The captain's commitment to landing or lack of understanding of the degree of instability of the flight path likely influenced the decision not to follow the aural GPWS alerts and the missed approach call from the first officer.

4. The non-standard wording and the tone used by the first officer were insufficient to deter the captain from continuing the approach.

5. At touchdown, directional control was lost, and the aircraft veered off the runway with sufficient speed to prevent any attempts to regain control.

Finding as to Risk

1. Companies which do not have ground proximity warning system procedures in their standard operating procedures may place crews and passengers at risk in the event that a warning is received.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 26 September 2012. It was officially released on 03 October 2012.

Visit the Transportation Safety Board's website (www.bst-tsb.gc.ca) for information about the Transportation Safety Board and its products and services. You will also find the Watchlist, which identifies the transportation safety issues that pose the greatest risk to Canadians. In each case, the TSB has found that actions taken to date are inadequate, and that industry and regulators need to take additional concrete measures to eliminate the risks.

Appendix A - Flight Safety Foundation Recommended Elements of a Stabilized Approach [8]

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC).

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

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V REF + 20 knots indicated airspeed and not less than V REF:
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing. An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC, or below 500 feet above airport elevation in VMC requires an immediate go-around.

Unstabilized approaches are attributed to:

- Fatigue;
- Pressure of flight schedule (making up for delays);
- Any crew-induced or ATC-induced circumstances resulting in insufficient time to plan, prepare and conduct a safe approach. This includes accepting requests from ATC to fly higher/faster or to fly shorter routings than desired;
- ATC instructions that results in flying too high/too fast during the initial approach;
- Excessive altitude or excessive airspeed (e.g., inadequate energy management) early in the approach;
- Late runway change (lack of ATC awareness of the time required by the flight crew to reconfigure the aircraft for a new approach);
- Excessive head-down work (e.g., flight management system [FMS] reprogramming);

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8 Flight Safety Foundation, Approach and Landing Accident Reduction (ALAR) Task Force (V1.1 November 2000).

- Short outbound leg or short downwind leg (e.g., because of traffic in the area);
- Late takeover from automation (e.g., because the auto pilot [AP] fails to capture the glideslope);
- Premature descent or late descent caused by failure to positively identify the final approach fix (FAF);
- Inadequate awareness of wind conditions, including:
    - Tail-wind component;
    - Low-altitude wind shear;
    - Local wind gradient and turbulence (because of terrain or buildings); or,
- Recent weather along the final approach path (e.g., wind shift or downdrafts caused by a descending cold air mass following a rain shower);
- Incorrect anticipation of aircraft deceleration characteristics in level flight or on a 3° glide path;
- Failure to recognize deviations or failure to adhere to the excessive-parameter-deviation limits;
- Belief that the aircraft will be stabilized at the minimum stabilization height or shortly thereafter;
- Excessive confidence by the PNF that the pilot flying (PF) will achieve a timely stabilization;
- PF-PNF too reliant on each other to call excessive deviations or to call for a go-around; and,
- Visual illusions

Appendix B - Runway Excursion Diagram