為什麼和何時要重飛

龍文馨 譯

航空業統計顯示，僅有百分之三的商用飛機進場落地時，處於不穩定進場的狀態，而這些處於不穩定進場的飛機，有百分之九十七會違反航空公司的標準操作程序，選擇繼續落地。

大多數偏離跑道的事件或多或少都和不穩定進場有關，而各種偏離跑道的型態是飛行意外或失事的首要原因，航空公司應向飛航組員強調，進場降落時只要是處於任何不穩定進場的狀態，適當的下定決心重飛，是非常重要的。

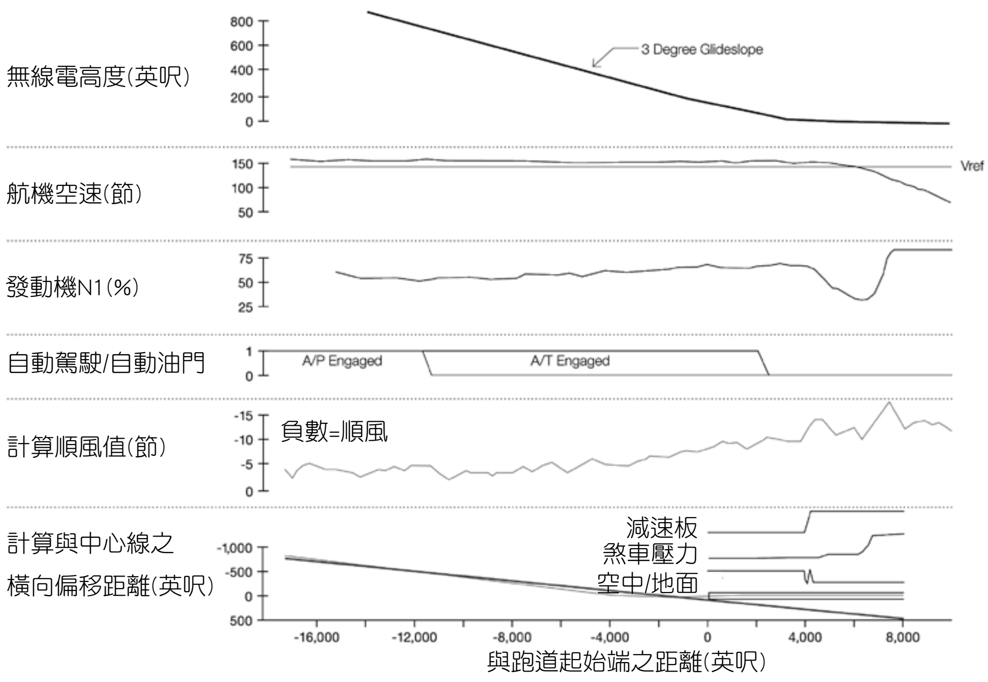
By Michael Coker, Lead Safety Pilot, Flight Services 根據航空業界資料顯示，沒有一個單一的決定會像及時決定重飛那樣，對全航空業的失事率有如此潛在的衝擊。因為偏離跑道和衝出跑道，是典型不穩定進場沒有重飛，所造成的後果--這大約佔商用航空飛行失事的百分之三十三，且是造成航機全毀的主因。

本篇文章說明飛機不穩定進場和飛機全毀的關聯性，為什麼飛行組員不理會不穩定進場還繼續落地，不穩定進場影響到落地結果，當在不穩定進場狀態，組員應該選擇重飛，航空業者也要努力的從事重飛的相關教育。

不穩定進場和全毀之間的關聯性

波音發展出一套系統以協助分析目視跑道的飛安事件。波音的跑道軌跡分析結合了多套的調查資料，包括了以時間為基準的飛行資料紀錄，以距離為基準的地面痕跡資料和計算的軌跡。(見圖一)

Flgure 1：Boeing 跑到軌跡分析



這分析顯示由於偏離跑道而飛機全毀與不穩定進場的關係。(見圖二)

		著陸點 (TD)		著陸速度		減速條件				結果	
						減速板使用 (SB)	反向推力使用 (TR)		跑道		
	進場狀態	著陸點 (英呎)	已使用跑道 (% LDA)	空速 >Vref (節)	順風 (節)	減速板展開時間 (秒)	反向推力使用時間 (秒)	反向推力收起高度 (英呎)	煞車狀況	速度超限 (節)	機殼受損
距離	不穩定進場	7,000	72%	23	0	TD	TD + 3	起飛離場	良好	81	是
	不穩定進場	6,200	70%	12	5	TD	從未使用		乾	50	否
	不穩定進場	5,300	60%	16	3	TD	TD + 4	起飛離場	良好	35	否
	不穩定進場	5,150	48%	20	0	TD + 5	TD + 7	900	中等	70	否
	不穩定進場	4,700	52%	30	-1	TD	TD + 2	1,000	—	100	是
	不穩定進場	4,500	60%	-3	1	TD	TD + 2	起飛離場	良好	47	是
	不穩定進場	4,500	56%	6	3	TD	TD + 3	400	乾	90	是
	穩定進場	3,950	44%	0	14	TD	TD + 3	起飛離場	中度	63	是
	穩定進場	3,260	41%	20	-1	TD	TD + 3	2,000	中度	40	否
	穩定進場	3,200	48%	-7	4	With TR	TD + 2	起飛離場	良好	30	否
	穩定進場	3,120	42%	10	10	TD	TD + 2	起飛離場	良好	50	否
	穩定進場	3,000	37%	-5	6	TD	TD + 2	起飛離場	中等	30	否
	穩定進場	3,000	34%	3	5	TD	TD + 3	起飛離場	中等	5	否
		13									
速度過快	穩定進場	1,600	20%	12	10	TD	TD + 27	起飛離場	良好	25	否
	穩定進場	1,500	20%	20	10	TD	TD + 3	600	中等	5	否
	穩定進場	1,450	20%	11	15	TD	TD + 3	1,250	中等	20	否
	穩定進場	1,450	20%	6	9	TD	TD + 3	起飛離場	中等	0	否
	穩定進場	1,250	18%	4	11	TD	TD + 2	起飛離場	不好	45	否
				5							
減速狀態	穩定進場	2,700	30%	0	0	從未使用	從未使用		中等	45	否
	穩定進場	400	6%	2	-6	從未使用	TD + 22	起飛離場	中等	48	否
	穩定進場	500	8%	3	4	With TR	TD + 20	起飛離場	中等	32	否
	穩定進場	1,250	21%	0	9	TD	TD + 16	起飛離場	不好	42	否
	不穩定進場	1,720	27%	6	5	TD+9	TD + 13	起飛離場	良好	20	否
	不穩定進場	1,800	23%	10	2	With TR	TD + 11	起飛離場	不好	28	否
	穩定進場	1,900	26%	6	-2	TD	TD + 8	起飛離場	中等	20	否
	穩定進場	1,150	24%	5	-5	TD	TD + 6	100	中等	12	否
	穩定進場	2,900	28%	0	-6	TD + 3	TD + 5	2,800	不好	10	否
	穩定進場	2,600	31%	0	2	TD	TD + 2	2,250	良好	25	否
	穩定進場	2,200	27%	5	7	TD	TD + 2	2,000	中等	45	否
							11				

對每一個飛機全毀的例子而言，如果組員選擇執行重飛以取代繼續落地，結果會截然不同。根據飛安基金會的一項研究，2011年所有商用飛機的失事事件有過半可因重飛的決定而避免。事實上根據飛安基金會的分析，百分之八十三的進場及落地的失事事件可因重飛而避免。

這份分析的結論是組員應該知道何時要放棄進場落地並執行重飛，因為重飛的決定是安全飛行的重要因素。

為何飛行組員在不穩定進場仍繼續落地

根據美國飛安基金會的研究，有些因素會導致飛航組員在不穩定進場的情況下仍決定繼續落地，包括

· 疲勞。

· 班機時間壓力(例如：想彌補班機之延誤)。

任何因飛航組員或航管因素所造成的沒有足夠時間

去計畫、準備，來執行一次安全的進場。
- 航管的指令造成在初期進場時過高及/或太快。
- 在初期進場時太高或速度太大。(例如：能量管理不當)。
- 太晚更換降落跑道。
- 在駕駛艙中低頭過分專注的工作。
- 缺少或過短的進場三邊(下風邊)(因為區域裡有其他航機)。
- 太晚解除自動駕駛。
- 由於沒有確認最後進場定位點，以致未準備好，而下降太晚。
- 對風的情況沒有適度的警覺。
- 對飛機平飛時和三度下滑角時的減速特性，有不正確的預期。
- 監控機師(Pilot Monitoring)過度相信操控機師(Pilot Flying)能及時的達到穩定狀態。
- 飛行組員太過互相依賴對方，而未呼叫出過大的偏離或重飛。
- 視覺幻覺，造成飛行組員錯認飛機的位置，例如窄跑道給飛行組員飛機高於實際的錯覺。
- 缺乏公司的政策、文化規範和訓練，以指引組員在不穩定進場狀態下重飛，以取代繼續落地。
- 重飛操控之練習不足。

影響降落的因素

三個主要因素決定每一個落地的結果
- 落地點。剩餘跑道決定了能量的消除。一個穩定的進場對於適當的落地點有很大的影響。
- 落地時速度。決定有多少能量需要被消耗。
- 落地後的減速。決定能量消耗的效率。

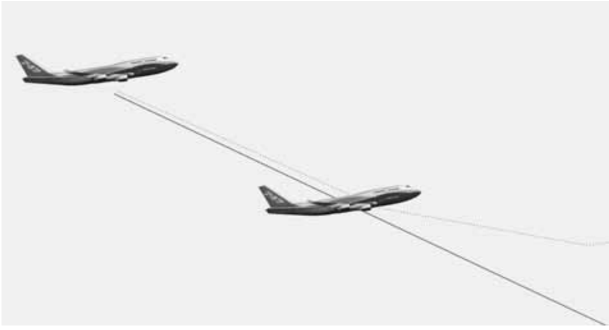
一項衝出跑道的分析顯示，如果三個因素裏有兩個存在，就很可能發生衝出跑道。如果去除其中一個，則衝出跑道的風險就減小了。

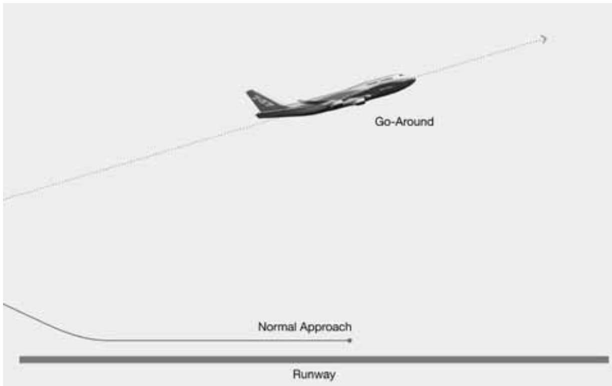
何時應當執行重飛

當飛機安全落地可能受到影響，就應當重飛。標準的說法是，只要有下列理由的一項，就要重飛：
- 航管要求。航管可能因為各種原因要求重飛，包括飛機間隔過小、有其他飛機還在跑道上，或有飛機太過接近落地的平行跑道。
- 非預期的事件。組員可能認為落地有些不太對勁—例如襟翼表或起落架指示—需要完成檢查單以確認航機落地構型。風切的出現也是另一個造成不預期重飛的因素。

甚至飛機在穩定進場落地以後，如跑道情況，地面風，跑道磨擦係數，或者任何與在進場時接獲的報告相抵觸，這些非預期的事件也可能造成重飛。

如果條件許可，在落地後組員還沒制動反推力之前，都可以成功的重飛。因為這些非預期的事件是難以預料的。
- 不穩定進場。當飛機無法於下列一種或多種的因素保持穩定：速度、下降率、垂直/水平航跡和落地外型。了解穩定進場並不只應用在儀器天氣1,000呎(305公尺)時和目視天氣500呎(152公尺)時的”





門檻”是非常重要的。這個高度只是一個進場分析的參考，在整個落地的過程都需要保持。(請參考本文結尾所建議的穩定進場元素)

· 無法在落地區內落地。其定義是最初的3,000呎(915公尺)或跑道最初的三分之一，取其短者。組員對每一個落地應該基於現行情況計算落地距離，將之與可用跑道做比較。如果在平飄或落地的最後時刻情況改變，即使在可接受的最初3,000呎(915公尺)或最初的三分之一跑道盡頭落地，也會變的不合適。

航空業界教育的成效

許多航空公司的機師協會和主管官署所辦對飛行組員有關重飛議題的教育，皆有相當成效。包括飛安基金會(FSF)、國際民航組織(ICAO)、國際航空運輸協會、商用航空安全小組(CAST)和歐洲商用航空安全小組。

資源包括：

· 飛安基金會的減少進場及落地失事的教材簡報資料(http://flightsafety.org/files/alar_bn6-1-goaroundprep.pdf).。

· 國際民航組織的研究報告，防止因不穩定進場而造成衝出跑道的各種條件（http://www.icao.int/Meetings/a38/Documents/WP/wp302_en.pdf).。

· 商用航空安全小組的有關重飛安全的研究（http://www.skybrary.aero/index.php/Portal:Go-Around_Safety)。

總結

偏離跑道是航空業界發生意外和失事主要的原因。如果飛行組員選擇重飛以取代繼續不穩定進場的落地，航空公司將可以避免大多數的偏離跑道事件。組員應該了解，當他們遭遇不穩定進場或在改平飄或落地的情況改變且未制動反推力之前， 決定重飛是非常重要的。

建議的穩定進場元素

在儀器天氣(IMC)狀況下，所有的飛行都必須在距機場標高1,000呎(305公尺)時，達到穩定的狀態，和在目視天氣(VFR)的情況，在距機場標高500呎(152公尺) 時達到穩定的狀態。當下列條件都符合時，就是穩定的進場：

1.飛機在正確的飛行航跡。

2.只需要很小量的航向和俯仰修正，就能保持正確的飛行航跡。

3.指示空速不大於Vref+20浬，不低於Vref。

4.飛機在正確的落地外型。

5.下降率不大於每分鐘1,000呎(FPM)或每分鐘305公尺。如果進場的下降率有需要大過每分鐘1,000呎(FPM)，則需要做一個特別的提示。

6.正確的馬力配置與外型匹配，且不低於飛機操作手冊的進場最低馬力。

7.所有的提示和檢查單都已完成。

8.如果達到下列條件則也可算特殊形態的穩定進場：在儀降系統的進場，必須飛在下滑道和水平航道(Glide Slop和Localizer)在一個dot之內，在第二類Category II或第三類Category III的儀降系統，必須飛在expanded localizer band，當環繞進場在最後階段距機場300呎(91公尺)高度時，航機機翼必須保持水平。

9.特殊進場程序或不正常情況，需要偏離以上穩定進場元素時，需要特別的提示。在儀器天氣航機低於機場高度1,000呎(305公尺)或在目視天氣低於機場高度500呎(152公尺)當航機處於不穩定狀態時，需要立刻重飛。

資訊來源：飛安基金會減少進場及落地失事研究小組。

譯自波音季刊 QTR 2, 2014

Why and When to Perform a Go-Around Maneuver

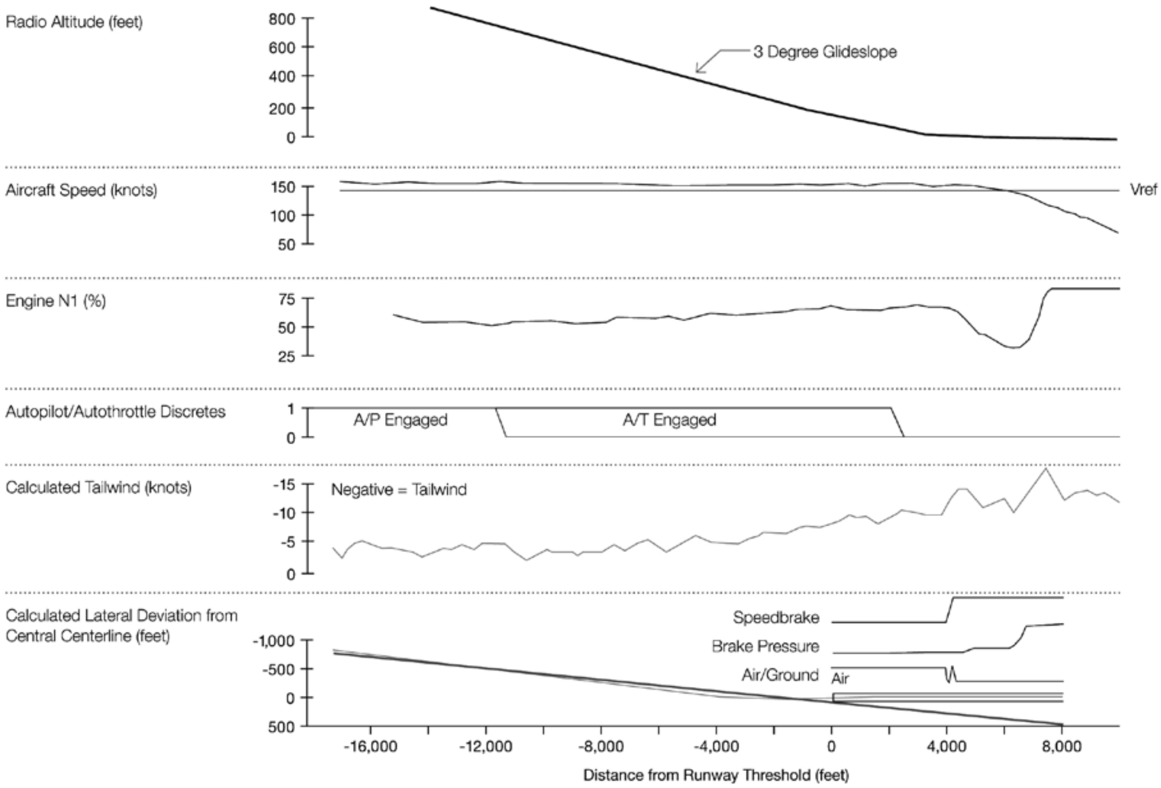
Michael Coker

Industry statistics indicate that while only 3 percent of commercial-airplane-landing approaches meet the criteria for being unstabilized, 97 percent of these unstabilized approaches are continued to a landing, contrary to airline standard operating procedures.

Most runway excursions can be attributed at least in part to unstabilized approaches, and runway excursions in several forms are the leading cause of accidents and incidents within the industry. Airlines should emphasize to flight crews the importance of making the proper go-around decision if their landing approach exhibits any element of an unstabilized approach.

According to industry sources, no single decision has the potential impact on the overall aviation industry accident rate than the timely decision to execute a

Figure 1: Boeing Runway Track Analysis
Boeing Runway Track Analysis uses a variety of data to analyze runway events.



go-around maneuver. The reason is that runway excursions or overruns — which are typically the result of an unstabilized approach with a failure to perform a go-around — account for 33 percent of all commercial aviation accidents and are the primary cause of hull loss.

This article explains the relationship between unstabilized approaches and hull loss, why flight crews continue landing despite an unstabilized approach, the factors that govern landing outcomes, when flight crews should choose a go-around maneuver, and industry education efforts related to go-arounds.

THE RELATIONSHIP BETWEEN UNSTABILIZED APPROACHES AND HULL LOSS

Boeing developed an analysis to help visualize runway events. This Boeing Runway Track Analysis combines multiple sets of investigation data, including time-based flight-data-recorder data, distance-based ground-scar data, and the calculated track (see fig. 1).

Figure 2: Relationship between unstabilized approach and hull loss
This analysis shows that four out of seven unstabilized approaches in this study resulted in hull loss.

		Touchdown Point (TD)		Touchdown Speed		Deceleration: Speedbrake (SB)	Deceleration: Thrust Reversers (TR)		Deceleration: Runway	Result	
	Approach	Point (feet)	Runway Used (% LDA)	Airspeed >Vref (knots)	Tail Wind (knots)	When SB Deployed (sec)	When TR Deployed (sec)	When TR Reduced (feet)	Braking Action	Overrun Speed (knots)	Hull Loss
Long	Unstable	7,000	72%	23	0	TD	TD + 3	Departure	Good	81	Yes
Long	Unstable	6,200	70%	12	5	TD	Never		Dry	50	No
Long	Unstable	5,300	60%	16	3	TD	TD + 4	Departure	Good	35	No
Long	Unstable	5,150	48%	20	0	TD + 5	TD + 7	900	Med	70	No
Long	Unstable	4,700	52%	30	-1	TD	TD + 2	1,000	—	100	Yes
Long	Unstable	4,500	60%	-3	1	TD	TD + 2	Departure	Good	47	Yes
Long	Unstable	4,500	56%	6	3	TD	TD + 3	400	Dry	90	Yes
Long	Stable	3,950	44%	0	14	TD	TD + 3	Departure	Med	63	Yes
Long	Stable	3,260	41%	20	-1	TD	TD + 3	2,000	Med	40	No
Long	Stable	3,200	48%	-7	4	With TR	TD + 2	Departure	Good	30	No
Long	Stable	3,120	42%	10	10	TD	TD + 2	Departure	Good	50	No
Long	Stable	3,000	37%	-5	6	TD	TD + 2	Departure	Med	30	No
Long	Stable	3,000	34%	3	5	TD	TD + 3	Departure	Med	5	No
		13									
Fast	Stable	1,600	20%	12	10	TD	TD + 27	Departure	Good	25	No
Fast	Stable	1,500	20%	20	10	TD	TD + 3	600	Med	5	No
Fast	Stable	1,450	20%	11	15	TD	TD + 3	1,250	Med	20	No
Fast	Stable	1,450	20%	6	9	TD	TD + 3	Departure	Med	0	No
Fast	Stable	1,250	18%	4	11	TD	TD + 2	Departure	Poor	45	No
				5							
Deceleration	Stable	2,700	30%	0	0	Never	Never		Med	45	No
Deceleration	Stable	400	6%	2	-6	Never	TD + 22	Departure	Med	48	No
Deceleration	Stable	500	8%	3	4	With TR	TD + 20	Departure	Med	32	No
Deceleration	Stable	1,250	21%	0	9	TD	TD + 16	Departure	Poor	42	No
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Deceleration	Unstable	1,800	23%	10	2	With TR	TD + 11	Departure	Poor	28	No
Deceleration	Stable	1,900	26%	6	-2	TD	TD + 8	Departure	Med	20	No
Deceleration	Stable	1,150	24%	5	-5	TD	TD + 6	100	Med	12	No
Deceleration	Stable	2,900	28%	0	-6	TD + 3	TD + 5	2,800	Poor	10	No
Deceleration	Stable	2,600	31%	0	2	TD	TD + 2	2,250	Good	25	No
Deceleration	Stable	2,200	27%	5	7	TD	TD + 2	2,000	Med	45	No
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This analysis shows the relationship between unstabilized approaches and hull loss, due to runway excursion (see fig. 2). In every instance of hull loss, the outcome may have been very different if the flight crews involved had elected to perform a go-around instead of attempting a landing. According to a Flight Safety Foundation (FSF) study, more than half of all commercial airplane accidents in 2011 could have been prevented by a go-around decision. In fact, according to FSF's analysis 83 percent of approach-and-landing accidents could be prevented by a go-around decision.

The conclusion from this analysis is that flight crews need to know when to abandon an approach to landing and perform a go-around maneuver because the decision to go around is an essential element of conducting a safe flight.

WHY FLIGHT CREWS CONTINUE LANDING WITH AN UNSTABILIZED APPROACH

According to the FSF, a number of factors contribute to a flight crew's decision to continue landing with an unstabilized approach, including:

- Fatigue.
- Pressure of flight schedule (e.g., making up for delays).

Any crew-induced or air-traffic-control (ATC)-induced circumstances resulting in insufficient time to plan, prepare, and conduct a safe approach.

- ATC instructions that result in flight too high and/or too fast during the initial approach.
- Excessive altitude or excessive airspeed (e.g., inadequate energy management) during the initial approach.
- Late runway change.
- Excessive head-down work.
- Short or short downwind leg (e.g., because of traffic in the area).
- Late takeover from automation.
- Premature or late descent caused by failure to positively identify the final approach fix.
- Inadequate awareness of wind conditions.
- Incorrect anticipation of airplane deceleration characteristics in level flight or on a three-degree glide path.

- Excessive confidence by the pilot monitoring (PM) that the pilot flying (PF) will achieve a timely stabilization.
- PF and PM too reliant on each other to call excessive deviations or to call for a go-around.
- Visual illusions that cause a crew to misinterpret the airplane's position, such as a narrow runway that may give the impression that the airplane is higher than it actually is.
- Lack of airline policy, cultural norm, and training to direct pilots to perform a go-around instead of continuing an unstabilized approach.
- Lack of practice in performing a go-around maneuver.

FACTORS THAT GOVERN LANDING OUTCOME

Three primary factors govern the outcome of every landing:

- Touchdown point. Defines runway remaining to dissipate energy. Having a stabilized approach contributes heavily to a proper touchdown point.
- Touchdown speed. Defines energy to be dissipated.
- Deceleration after touchdown. Defines the effectiveness of dissipating the energy.

An analysis of overruns indicates that if two out of three conditions exist, an overrun is likely. But if one condition is removed, the overrun risk is reduced.

WHEN TO PERFORM A GO-AROUND MANEUVER

A go-around maneuver should be performed whenever the safety of a landing appears to be compromised. (see fig.3) Typically, this occurs for one of these reasons:

· Requested by ATC. ATC may request a go-around for a variety of reasons, including tight airplane spacing, an airplane on the runway, or an airplane too close on a parallel landing runway.

· Unexpected events. The flight crew may determine that something is not correct for landing — such as a flap gauge or gear indication — and that a checklist is needed to configure the airplane for landing. The presence of wind shear is another unexpected cause of go-arounds.

These unexpected events may warrant initiation of a go-around even after the airplane has touched down following a stable approach. Runway conditions, surface winds, friction coefficients, or unknown conflicts may be different than those reported to the crew during approach. A successful go-around may be possible after touchdown up to the point where the crew initiates the use of thrust reverse if conditions warrant.

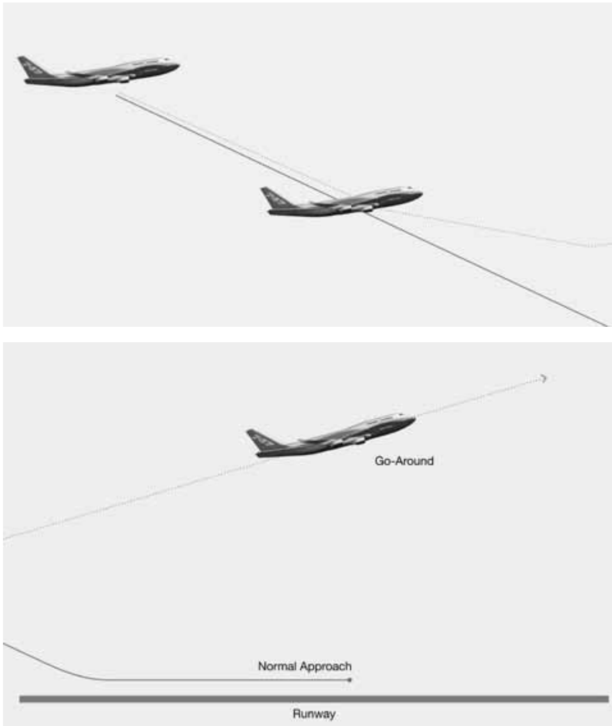
Because these types of go-arounds involve unexpected events, it is difficult to anticipate them.

· Unstabilized approach. An unstabilized approach occurs when an airplane fails to keep one or more of these variables stable: speed, descent rate, vertical/lateral flight path, and configuration for landing. It is important to understand that the stabilized approach recommendations do not apply only to the "gates" of 1,000-foot (305-meter) instrument meteorological conditions (IMC) and 500-foot (152-meter) visual meteorological conditions (VMC). Those altitudes are merely a snapshot analysis of the approach, and the elements need to be maintained throughout the landing.

(See "Recommended elements of a stabilized approach" at the end.)

· Landing cannot be made within the touchdown zone. This is defined as the first 3,000 feet (915 meters) or first third of the runway, whichever is shorter. Crews should calculate a landing distance based on current conditions and compare that distance to the runway available for every landing. Touchdown at the far end of the accepted first 3,000 feet (915 meters) or first third of the runway may not be appropriate if conditions change at the last moment during the flare or touchdown.

Figure 3: When to perform a go-around
The timely decision to initiate a go-around if the approach is unstable or conditions have changed, such that a safe landing is at risk, allows the crew to safely conduct a follow-on approach. There are several reasons to perform a go-around maneuver, including a request by ATC, an unexpected event (such as wind shear), an unstabilized approach, or the determination that the landing cannot be made within the touchdown zone.



INDUSTRY EDUCATION EFFORTS

Numerous airline pilot associations and regulatory authorities have efforts under way to educate flight crews about go-arounds. These include the FSF, International Civil Aviation Organization (ICAO), International Air Transport Association, Commercial Aviation Safety Team (CAST), and European Commercial Aviation Safety Team.

Resources include:

· FSF Approach-and-Landing Accident Reduction

Tool Kit Briefing Note, *Being Prepared to Go Around* (http://flightsafety.org/files/alar_bn6-1-goaroundprep.pdf).

· ICAO Working Paper, *Measures for Preventing Runway Excursion Caused by Unstabilized Approach* (http://www.icao.int/Meetings/a38/Documents/WP/wp302_en.pdf).

· CAST Go-Around Safety (http://www.skybrary.aero/index.php/Portal:Go-Around_Safety).

SUMMARY

Runway excursions are the leading cause of accidents and incidents within the industry. Airlines can avoid most runway excursions if flight crews choose to execute a go-around maneuver instead of continuing an unstabilized approach to a landing. Flight crews should understand the importance of making a go-around decision if they experience an unstabilized approach or conditions change during the flare or touchdown up to the point of initiating thrust reverse during the landing rollout.

Recommended elements of a stabilized approach

All flights must be stabilized by 1,000 feet (305 meters) above airport elevation in instrument meteorological conditions (IMC) and by 500 feet (152 meters) above airport elevation in visual meteorological conditions (VMC). An approach is stabilized when all of the following criteria are met:

1. The airplane is on the correct flight path.
2. Only small changes in heading/pitch are required to maintain the correct flight path.
3. The airplane speed is not more than Vref + 20 knots indicated airspeed and not less than Vref.
4. The airplane is in the correct landing configuration.
5. Sink rate is no greater than 1,000 feet per minute (FPM) or 305 meters per minute; if an approach requires a sink rate greater than 1,000 FPM, a special briefing should be conducted.
6. Power setting is appropriate for the airplane configuration and is not below the minimum power for approach as defined by the airplane 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 glide scope and localizer; a Category II or Category III ILS approach must be flow within the expanded localizer band; during a circling approach, wings should be level on final when the airplane reaches 300 feet (91 meters) above airport elevation.
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 (305 meters) above airport elevation in IMC or below 500 feet (152 meters) above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach and-Landing Accident Reduction Task Force.

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