
N637TW

GENERAL

Each aircraft operator is invited to review and prioritise the proposed action plan for implementation. The following guidance material is provided to assist in that implementation.

Safety Information Sharing

Recommendation 3.4.1 Aircraft operators are encouraged to participate in safety information sharing networks to facilitate the free exchange of relevant information on actual and potential safety deficiencies.

Exchanging safety information is providing companies with huge safety benefits. It allows them to learn not only from their own experience but also from the experience of others.

Having direct contact with other stakeholders allows companies to get first hand information. Direct contact also provides the opportunity to ask specific questions and communicate on specific issues without losing precious time.

There are several ways of participating in safety information exchange.

A company may elect to:

- Set up safety information exchange agreements with other companies
- Set up safety information exchange agreements with ANSPs or other stake holders
- Register with internet safety information exchange like Skybrary, UK CAA, etc
- Join one of the existing safety information sharing networks like EVAIR, IATA-STEADES, Flight Safety Foundation
- Become a member of associations like ERA, AEA, IATA who will provide the company with very useful and valuable information

Flight Data Monitoring

Recommendation 3.4.2 The aircraft operator should include and monitor aircraft parameters related to potential runway excursions in their Flight Data Monitoring (FDM) program.

European regulation requires aircraft operators to establish and maintain an accident and flight safety program which includes a flight data monitoring programme (FDM) for aeroplanes in excess of 27.000kg.

The flight path parameters monitored by this system should include parameters closely related to the risk of runway excursion such as:

Landing:

- Deep landing – a certain distance behind the glide slope touchdown point
- Short landing – touching down before the glide slope touchdown point
- Long flare – a landing flare which takes more than a certain number of seconds from e.g. 15 ft above the runway to touchdown
- Monitor spoiler deployment during landing
- Late flaps settings – can be associated with rushed approaches
- Late landing gear selection – can be associated with rushed approaches
- Tail and crosswind
- Stabilised approach criteria of the company, event if not met at the specified gates
- Threshold crossing height
- Excess speed over the threshold
- Use of reverse thrust
- Use of brakes
- High speed exits from runways
- Performance analysis e.g. to trigger alerts to the Aerodrome Operator for abnormally low friction measures.

Takeoff:

- Use of reverse on rejected takeoff
- Use of brakes on rejected takeoff
- Nose wheel steering used at high speeds
- Runway distance remaining after rejected takeoff
- Crosswind and tailwind

FDM should be used as a predictive tool to identify safety hazards in flight operations. In the scope of a Safety Management System (SMS) the data from the FDM should be used to set safety performance targets. It is also a very valuable tool to debrief flight crews. Data can be extracted from the FDM database and can be used in a de-identified manner in flight crew safety courses as case studies. This practice has a great learning effect and helps to raise awareness on different issues among the pilot community.

Flight Crew Training and Runway Excursion

Recommendation 3.4.3 The aircraft operator should include runway excursion prevention in their training program. This training should be done using realistic scenarios.

Flight crew training should contain training on the risks and prevention of runway excursions. Ideally this training should be provided in classroom/Computer Based Training and in the simulator. Data for the training should be identified through the safety data collection process of the aircraft operator's SMS.

The following list gives some examples of data sources:

- Runway excursion toolkits from the industry e.g. ICAO / IATA/Flight Safety Foundation
- Own reporting programme
- FDM data
- Company procedures
- Safety Information Exchange Programme with other aircraft operators
- In house incident and accident reports
- External incident and accident reports
- Safety conferences and meetings
- International safety programmes
- etc.

The safety promotion part of the SMS should also be used to distribute data and raise the crew's awareness on the prevention of runway excursions. Lessons learned from past incidents or accidents can easily be distributed using the following safety promotion tools:

- Memos
- Internal Safety Journal
- Feedback on incident reporting
- Safety Intranet Site
- Email briefings
- Presentations in courses
- etc

Airline specific issues as well as de-identified data from the FDM program should be included in the recurrent training programme, and used to build simulator scenarios (evidence based training).

The traditional way of flight crew training and testing consist in a 6 monthly OPC alternating with a combined LPC/OPC. This method is very prescriptive and doesn't allow for aircraft operator specific training and testing. This is why various aircraft operators have adopted the new Alternative Training and Qualification Programme (ATQP). For the OPC this programme allows the testing to be done in a realistic flight environment (LOFT style) based on failures or events that were experienced by the aircraft operator instead of the formal prescribed items in the OPC. Events and scenario's related to runway excursion can be easily included. This system allows the aircraft operator to train and test their flight crew according the specific nature of their operations.

Technical Solutions to Prevent Runway Excursions

Recommendation 3.4.4 The aircraft operator should consider equipping their aircraft fleet with technical solutions to prevent runway excursions.

The landing phase being very complex does not leave much mental capacity to make complex instantaneous calculations; so basic rules of thumb must be used.

Automated systems provide instantaneous information such as predicted stopping points to the pilots therefore improving their decision making.

Use of the Head up Guidance Systems for all approaches may help the pilots in their decision making. Most Head up Guidance Systems provide for a 3° slope indication, indicate the flight path and have a guidance line for the touchdown point. Using HGS for all approaches may assist the pilots to fly stabilised approaches. This is especially true for visual approaches when no vertical guidance (e.g. ILS, PAPI, VASI etc) is available. Most HGS systems also have the feature to show the runway remaining after touchdown.

Data-Link systems

> **Recommendation 3.4.5 The aircraft operator should consider equipping their aircraft fleet with data-link systems (e.g. ACARS) to allow flight crews to obtain the latest weather (D-ATIS) without one pilot leaving the active frequency.**

The use of data-link systems allows the flight crew to obtain current weather information without one pilot losing situational awareness. It also allows an improved follow-up in a rapid changing weather environment.

The use of data-link systems should be clearly documented in the company procedures. The procedures should also contain limitations on phases of flight during which data-link systems should not be used anymore (e.g. during the final approach phase).

Collaboration with ANSP

> **Recommendation 3.4.6 The aircraft operator should report to the ANSP if approach procedures or ATC practices at an airport prevent flight crew from complying with the published approach procedure and their stabilised approach criteria.**

It is important to understand that stabilised approach criteria must be followed and that, if the ATC clearance does not allow these criteria to be followed, the pilots have the right to refuse the clearance.

Refusing a clearance should be done as soon as possible (e.g. as soon as the pilots recognise that the stabilised approach criteria will not be met) to allow the ATC controller to review his/her traffic sequencing.

Some examples of clearances which may lead to unstabilised approaches are:

- Inappropriate speed control
- Delayed descent instructions
- Late runway changes
- 'Short cuts' vectoring
- etc

NOTE:
In some instances the ATC controller may not be able to adhere to standard procedures due to unforeseen circumstances (e.g. weather). Airline procedures should contain contingency procedures for these situations in order to allow their pilots to safely land the aircraft. However, it needs to be clear that these contingency procedures should not become the standard.

Pilots should proactively report any ATC clearance which is not in line with their SOPs. In the scope of the SMS this will allow the Safety Manager to identify negative trends and take appropriate actions.

Appropriate actions are:

- Reporting problems to the respective ANSP
- Checking if company SOPs are correct
- Identifying airports/approach procedures with potential risk
- Proactive meetings with respective ANSPs to tackle specific issues
- Feedback to crews to raise awareness, lessons learned
- Include specific issues in company safety training
- Exchange of data with other stakeholders (e.g. EVAIR, IATA-STAEDES or other aircraft operators in the scope of the Safety Information Exchange Programme)

Aircraft Operators should seek active cooperation with Local Runway Safety Teams of the airports in their route network.

Non Standard Manoeuvres

Recommendation 3.4.7 The aircraft operator should ensure the importance of a stabilised approach and compliance with final approach procedures is included in briefing for flight crews. The commander should not accept requests from ATC to perform non-standard manoeuvres when they are conflicting with the safety of the flight.

Flight crews are often confronted with ATC clearances or instructions they are not comfortable with.

Examples of this are:

- Controllers giving a tight base-turn
- Controllers asking to keep the speed up
- Controllers asking to expedite vacating the runway
- Controllers giving late runway changes
- etc.

These clearances are often well intended but do not always take into consideration the high workload on the flight deck during the last minutes of the flight. They might even lead pilots to accept a clearance which will make the safe operation of the aircraft a challenge.

Pilots may be reluctant to refuse ATC clearances.

There are many different reasons for this:

- Pilots do not know that they are 'allowed' to refuse an instruction
- Pilots might not realise which situation they are being pushed into
- Pilots do not want to offend the controller by refusing the instruction
- Cultural issues might give the ATC instruction the status of an 'order'
- Felt or real commercial pressure to accept 'short cuts'
- The deviation has become the standard
- etc.

One thing should be clear to all flight crew they shall refuse any ATC instruction which is conflicting with the safety of flight.

In the scope of aircraft operators' SMS it is important that crews understand the importance of reporting these issues. Safety managers will need data in order to be able to address these issues. Having enough data will allow the safety managers to address these issues to the respective ANSP.

A good practice for aircraft operators is to regularly meet with the ANSP at different airports and discuss issues which turned up. Very often these issues are based on misunderstandings (e.g. I thought pilots liked the short cuts we provided to them) or simply on the lack of knowledge about the limitations and procedures of each other (e.g. request to reduce speed and increase descent rates, or late descend clearance given to the pilots, whereas pilots do not understand that the clearance is offered due to airspace restrictions/constraints).

Meetings with the ANSP are a very proactive way of increasing the understanding of each other. The knowledge gained during these meetings should be disseminated to all crews in order to raise their awareness on discussed issues. This will enable the crews to know about 'safety issues' at different locations and thus be prepared for the 'unexpected'

A good industry practice is to have an exchange programme between ANSPs and aircraft operators in place. Meaning that controllers will be allowed to do familiarisation flights in the flight deck or in a flight simulator and that flight crews will visit the ANSP facilities. This will help to raise the understanding of each other's work constraints.

Runway Change

Recommendation 3.4.8 The Commander should not accept a late runway change unless for safety reasons. A briefing and if needed flight management computer (FMC) preparation must be completed (e.g. before leaving the gate or starting the final approach).

Late runway changes are an issue both for takeoff and for landing.

Late runway change for takeoff

A late runway change before takeoff, if not anticipated by the crew, will lead to a serious increase in workload for the crew. Crews should not accept a runway change unless a briefing, performance calculation and FMC preparation can be safely completed in due time.

NOTE:
One crew member will need to be head down to make all the changes required in the setup of the radio and navigation equipment. This should not be done while taxiing. During taxi both pilots should direct their full attention to the movement of the aircraft on the airport.

Issues which might arise from this are:

- Crews following the wrong taxi route
- Crews overlooking other traffic
- Runway incursions
- Discrepancies in the stored SID in the FMC leading to crew confusion or SID violations
- Errors in performance calculations which might lead to runway excursions
- etc.

Consideration should not only be given to reprogramming the new departure route and the corresponding setting of the radios but also to performance calculations. This is especially true if the late runway change includes or is a departure from an intersection.

Late runway change for landing

A late runway change for landing, if not anticipated by the crew, will lead to an increase in workload for the flight crew. Flight crews should not accept a runway change unless a briefing, including the go-around for the new runway, performance calculation and FMC preparation can be safely completed in due time. Ideally the runway change should not be accepted below FL100.

Crews should not start an approach until all of the above is completed.

Issues which might arise if all of the above is not completed before starting the approach are:

- Rushed and unstabilised approaches
- Wrong radio and navigation settings for approach
- Flying the wrong approach
- Not intercepting the cleared approach in time. This is especially critical on airports with parallel runway operations
- Flying the wrong go-around route
- Errors in performance calculations which might lead to runway excursions
- Discrepancies in the stored FMC data leading to crew confusion
- etc.

Where an aircraft is equipped with Flight Management Systems (FMS) capable of storing two flight plans, this feature should be used when the crew is preparing the arrival and there is a possibility for one of two different runways to be assigned for landing. The flight plan 'on stby' can be easily activated without a significant increase in workload.

ANSP often try to use the optimal runway configuration as long as possible for capacity reasons. While the surface wind might still be within the limits the winds at altitude are often well beyond these limitation making it harder for flight crew to stabilise their aircraft. In this case flight crew should not be reluctant to ask for a more appropriate runway; clearly stating that this is for safety reasons; even if this means delaying the approach.

WEATHER

Current Weather versus Forecasted weather

Recommendation 3.4.10 The Commander, shortly before takeoff and landing, shall verify that the actual weather conditions are similar or conservative compared to the weather data used for the takeoff performance calculations and the in-flight landing distance assessment.

Flight crews should check that the wind and runway conditions given with the takeoff or landing clearance is consistent with the one used for the performance calculations.

NOTE:
In headwind situations, to facilitate the cross-check, performance calculations, can be done with zero headwind so that the presence of any headwind will be conservative.

At the actual time of arrival weather conditions can be different from the ones used at time of dispatch or even from the time at which the approach briefing was performed. Flight crews should pay special attention to significant changes in wind direction and or runway surface conditions.

Flight crew shall check the latest weather information before their in-flight landing distance assessment is done. If sufficient time remains and cockpit duties allow it, crews shall always try to get the latest available weather information just prior to starting the approach. If during the approach the crews feel that the weather conditions have changed they may seek clarification on the actual conditions with the ATC controller.

CROSSWIND OPERATIONS

Operations in crosswind conditions not only require specific handling techniques, but also require good knowledge and strict adherence of the applicable crosswind limitations.

Understanding Crosswind Limitations

Recommendation 3.4.11 The aircraft operator should publish the Aircraft's Crosswind Limitations with specific guidance on the runway condition and the gust component.

The aircraft manufacturers publish maximum recommended crosswind values. Aircraft Operators should give clear guidance to their flight crews on how these values should be used. Some operators consider these maximum recommended values as actual aircraft limitations.

Specific guidance should be published on how flight crews should use the value of the wind gust.

The maximum recommended crosswind values also depend on the runway surface condition. Clear guidance should be given on the influence of this runway surface condition or reported braking action on the recommended values.

Example Airbus A320 family

CODE	RUNWAY CONDITION	DECELERATION AND DIRECTIONAL CONTROL OBSERVATION	REPORTED BRAKING ACTION	MAX CROSSWIND (GUST INCLUDED)[1]
6	Dry	-	**Dry**	38kt
5	Damp Wet	Braking deceleration is normal for the wheel braking effort applied. Directional control is normal	**Good**	33kt
	3 mm (1/8”) or less of ■ Slush ■ Dry Snow ■ Wet Snow Frost			29kt
4	Compacted Snow (OAT at or below -15°C)	Braking deceleration and controllability is between Good and Medium.	**Good to Medium**	29kt
3	Slippery when wet Compacted Snow (OAT at or above -15°C) More than 3 mm (1/8”) depth of: ■ Dry Snow – max 130 mm (5”) ■ Wet Snow – max 30 mm (1 1/8”)	Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be noticeably reduced.	**Medium**	25kt
2	Between 3 mm (1/8”) depth of : ■ Water – max 12.7 mm (1/2”) ■ Slush – max 12.7 mm (1/2”)	Braking deceleration and controllability is between Medium and Poor. Potential for Hydroplaning exists.	**Medium to Poor**	20kt
1	Ice (cold & dry)	Braking deceleration is significantly reduced for the wheel braking effort applied. Directional control may be significantly reduced.	**Poor**	15kt
0	Wet ice Water on top of Compact Snow Dry Snow or Wet Snow over Ice.	Braking deceleration is minimal to non-existent for the wheel braking effort applied. Directional control may be uncertain.	**Nil**	-

[1] In case of AUTOLAND, max crosswind limited to 20kt

Flight Technique in Crosswind Operations

Recommendation 3.4.12 The aircraft operator should publish specific guidance on takeoff and landing techniques with cross wind; and/or wet or contaminated runway conditions and the correct use of the nose wheel steering. Appropriate training must be provided.

Takeoff Technique:

Due to differences in flight technique between fly-by-wire and conventional aircraft only general guidance is presented. Aircraft manufactures publish specific guidance in the Flight crew Training Manual.

Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. Rolling takeoff procedure is strongly advised when crosswinds exceed 20 knots or tailwinds exceed 10 knots to avoid engine surge. Especially on wet or slippery runway conditions special attention should be paid to ensure the engines are spooling-up symmetrically. Light forward pressure on the yoke or side stick increases nose wheel steering effectiveness. Any deviation from the centerline during thrust application should be countered with immediate smooth and positive control inputs.

Approach Technique:

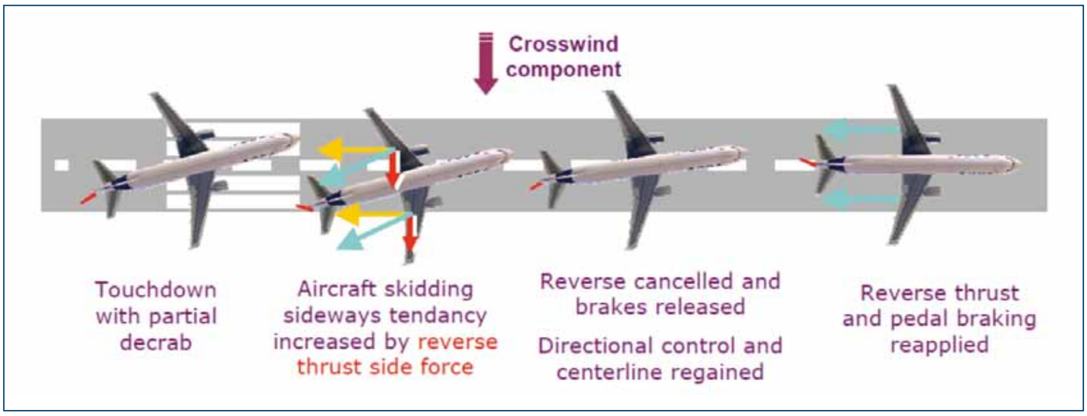
Aircraft Manufacturers consider several factors such as aircraft geometry, aileron and rudder authority when recommending a crosswind approach technique. This can be the wings-level or crabbed approach, the steady side-slip approach or a combination of both in strong cross-wind conditions.

In line with standard operating procedures, disconnect the autopilot at an appropriate altitude to have time to establish manual control of the aircraft well before the de-crab phase and flare.

Landing Technique:

Especially on wet or contaminated runways a firm touch-down is recommended to minimise the risk of aqua-planing and ensure a positive touchdown.
When touching down with residual crab angle on a dry runway the aircraft automatically realigns with the direction of travel down the runway. This is not happening on a wet or contaminated runway.

Residual crab angle on the runway has also some implications when reverse is selected.
In the case that a lateral control problem occurs in high crosswind landings, pilots must reduce reverse thrust to reverse idle and release the brakes to correct back to the centreline. This will minimise the reverse thrust side force component and provide the total tyre cornering forces for realignment with the runway centreline.



Working with the Flight Management Computer (FMC)

Recommendation 3.4.13 The aircraft operator should ensure their standard operating procedure (SOP) requires the flight crew to perform independent determination of takeoff data/crosscheck the results. The aircraft operator should ensure their Standard Operating Procedures include flight crew cross-checking the 'load and trim sheet' and 'performance' data input into the Flight Management Computer (FMC).

Traditionally the dispatcher will provide the Flight crew with the load and trim sheet or loading form containing all the loading information. In some instances the flight crew will have to complete the load and trim sheet 'manually'. In this case the company should provide procedures for the pilots to independently crosscheck the data before it is being used for performance calculations.

The next step will be to use the data either to be entered into the EFB or to do the performance calculations on paper.

Performance calculation using the EFB

The information from the load and trim sheet may be entered in the loading module of the Electronic Fight Bag (EFB) to obtain the weights and trim settings for takeoff. This data is then used in the performance module to generate the takeoff performance data. It is highly recommended that each pilot perform his own calculation and then crosscheck it with the other pilot's result. In case where a class 1 EFB is used for the performance calculation each crew member must be provided with one EFB to ensure proper independence of calculation and crosscheck. The calculation should be done prior to receiving the final load and trim sheet when the actual load can be ascertained with reasonable accuracy to avoid errors due to time pressure and hurry up syndrome.

Performance calculation using paper version

The information from the load and trim sheet is then used to determine the takeoff performance data. This data will be written down on the company documentation and shall be crosschecked by the other crew member. The performance data are then inserted by one pilot into the performance page of the FMC and again carefully checked by the other pilot.

In both cases the flight crew should also check the 'reasonableness' of the takeoff reference speeds and thrust setting; which can be challenging for flight crew operating in a mixed fleet environment.

As a backup, technology providers should develop a system that automatically checks the data entered into the FMC for consistency between the take of parameters (e.g. Take Off Securing (TOS) by Airbus).

This data insertion is usually done just before departure when the flight crew is exposed to various distractions. The Operator's CRM training should provide threat and error management guidance on how to mitigate the threats posed by these distractions. Special guidance should also be provided for cabin crew and handling agents not to disturb flight crew while they are performing data insertions or briefings.

Flight crew training is based on monitoring and responding to the attainment of takeoff reference speeds, but they have little 'human' means in detecting reduced or degraded takeoff acceleration until approaching the end of the runway. Technology providers have an important role to develop systems that provide alerts to the flight crew when the actual acceleration is too low to allow a safe takeoff, example Takeoff monitoring (TOM) by Airbus.

Furthermore the FDM programme should be used to identify issues in relation to performance calculations, slow acceleration etc. In the scope of the SMS promotion any issues discovered should be fed back to the crews to raise their awareness and share the lessons learnt.

The Rejected Takeoff Decision Process

Recommendation 3.4.14 The aircraft operator should publish the rejected takeoff decision making process. Appropriate training should be provided.

Takeoff speeds are key elements in a safe takeoff. They are monitored by the pilot non-flying (PNF or PM) V1 is called by the PNF/PM or by the aircraft system; Vr is called by the PNF/PM. The most important speed range for failure management is just before V1, the maximum speed at which a rejected takeoff can be initiated.

There must be a clear policy about which pilot may call a STOP or GO on takeoff, as well as who will make the STOP actions.

To help the "decision maker" in his task, the takeoff roll is divided into a low and high speed segment. Typically the threshold is between 80knots and 100knots, below this speed the aircraft's energy is low and a rejected takeoff is considered low risk. Above this speed the aircraft's energy is high and a correctly executed rejected takeoff is considered critical.

The essential supporting and monitoring task of the pilot non flying should be emphasised. This includes:

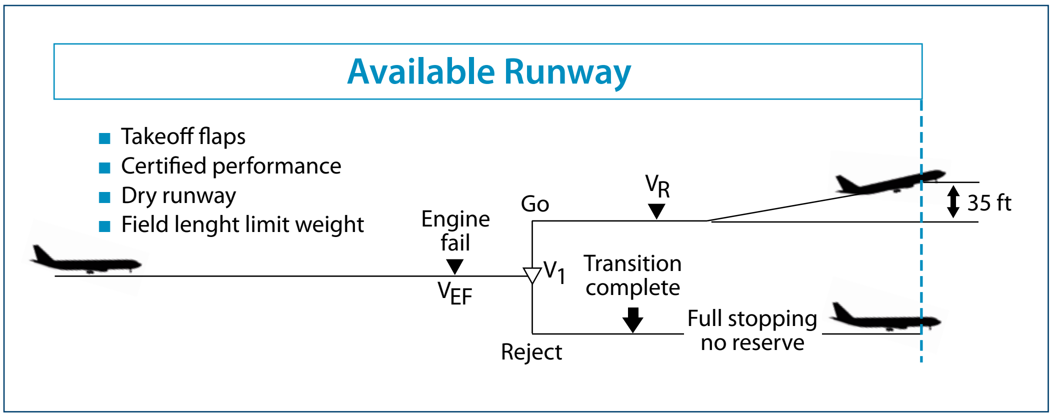
- Monitoring of thrust parameters
- Monitoring the speed trend
- Perform timely standard callouts
- Detect and/ identify any abnormal conditions
- Monitor the use of ALL braking devices

Training:

The rejected takeoff manoeuvre is a mandatory item in the Operators Proficiency Check (OPC), so flight crews are trained and assessed on the manoeuvre on a regular basis. However this assessment is mostly focussed on the correct execution of the manoeuvre and not on the decision making process.

It is strongly recommended that recurrent training and checking, and especially command upgrading courses, also include simulator exercises that require the flight crew to detect and identify abnormal situations that are not the result of a clear and distinct loss of thrust, such as:

- Engine stall
- Tyre burst close to V1



Airline Policy:

Aircraft Operators must define the policy, procedures and required task sharing for a rejected takeoff. It should include the decision making process for a STOP or GO event and the task sharing between the Commander and First Officer as well as the PF and PNF/PM.

- Nose gear vibrations
- Bird strike at high speed
- Wind shear or uneven aircraft acceleration
- Opening of side window
- Instrument failures
- Flight control issues

In-flight assessment of landing performance

Recommendation 3.4.15 The aircraft operator should publish and provide training on the company policy regarding in-flight assessment of landing performance. Flight crew must be advised whether company landing distance data relates to unfactored or operational distances. In the case of unfactored distances the company should provide the safety margin to be used in normal and abnormal conditions.

While most flight crew are familiar with the dispatch requirements on landing performance which are based on un-factored actual landing distances (ALD), multiplied with a regulatory factor, they should be made aware that some manufacturers are basing their new in-flight landing performance on factored Operational Landing Distances (OLD). Aircraft Operators should provide unambiguous landing performance information to their flight crew.

The dispatch calculation usually yields results in weight limitation and not runway length required. Giving results in runway length required for dispatch calculations has two advantages: it requires the crew to be aware of the runway length available at the destination airport and it is possible to compare it with the in flight landing performance that gives results in length also.

Due to the variations of published landing performance data, aircraft operators must clearly inform their flight crew if the calculations are made using factored or unfactored landing distances. This may include declaring the following:

- what level of reverse thrust was assumed,
- the assumption of the wheel braking,
- if the data was factored or not,
- what was the air distance allowance in the data.

The in-flight assessment of landing performance calculation should be made using conservative wind component and runway condition according to the latest weather report and forecast available to the crew to know what weather conditions can be accepted for the landing to be safely performed. It is important to take into account the aircraft status and the latest weather information available. The flight crew should assess the weather with a conservative strategy in particular concerning the runway condition and the wind component.

As an example if the ATIS states runway in use 33 RWY dry, wind 250/10 gusting 25, visibility 9999 Vicinity RaSh, cloud sct 2500 sct 3000 Cb, temperature 32/25, QNH 1009 The crew has two options either they take the actual weather that gives RWY dry, no wind component, or they take the possible scenario of a shower passing on the runway when they will be landing i.e. runway wet (or contaminated) and a wind component of 5 to 10kt tailwind.

The first option is the more favourable case but doesn't prepare the crew for the decision to be taken in case of weather deterioration on short final. The second option will allow the crew to assess whether the landing can be made safely or not (what is the max tailwind and the runway condition he can accept) in this worst case.

So if on final ATC gives: runway wet and 230/ 15 gusting 20 clear to land runway 33, the decision to land or not will be based on sound performance calculation in the second option and on guesswork in the first option.

Specific guidance should be provided for wet or contaminated runway conditions and for failure cases.

Whilst European regulation makes a generic statement regarding the need to assess the landing performance in flight; Aircraft Operators should publish an SOP regarding the in-flight landing performance assessment as part of their approach preparation when:

- Landing on wet or contaminated runway
- Weather deterioration since dispatch
- Change of landing runway
- In-flight failure affecting landing performance
- Etc.

APPROACH

Runway and Approach Type Selection

Recommendation 3.4.17 When accepting the landing runway the Commander should consider the following factors: weather conditions (in particular cross and tailwind), runway condition (dry, wet or contaminated), inoperable equipment and aircraft performance. Except in conditions that may favour a non precision approach, when more than one approach procedure exists, a precision approach should be the preferred option.

Recommendation 3.4.20 The aircraft operator should publish guidelines on the use of autoland when low visibility procedures (LVP) are not in force. Flight crew that practice automatic landings without LVP in force should take into account status of the protected area for the Localiser signal. Flight crew should fully brief such practice manoeuvres, in particular, readiness to disconnect the autoland/automatic rollout function and land manually, or go-around.

Manual flying skills:

Generally aircraft operators encourage the use of the highest level of automation appropriate to the phase of flight or the airspace in which the flight is being conducted in order to reduce crew workload and increase situational awareness. However it's recognised that to maintain the proficiency of manual flying skills flight crew should fly the aircraft manually on a regular basis when appropriate. When a pilot is flying the aircraft manually it increases the flight crew workload and requires more coordination between the pilots. The intention to fly the aircraft manually should be briefed in advance together with any intended use of partial automation (e.g. auto thrust).

Automatic Landing:

Aircraft operators who are authorised to perform low visibility operations (LVO) generally maintain the recency of their flight crew with a recurrent training program in the simulator. However initial type rating conversion generally requires an automatic landing to be performed during line training.

Flight crew should be aware that the ILS signal is only protected from possible interference when low visibility procedures (LVP) are in force at an airport and that these operations may compromise the regular flow of traffic/sequencing. Permission to conduct a training flight e.g. CAT II/III training approach in good weather must be requested by the aircraft operator as advised in the AIP. ATC may reject such a request or interrupt the current procedure according to the traffic situation at the time.

Aircraft operators' standard operating procedure should give the minimum weather conditions and ILS performance allowing an autoland to be performed without LVP in force. Flight crew should be aware ILS interferences can cause undesirable autopilot behaviour at low altitude. Flight crew should therefore be ready to disconnect the autopilot and go-around or land the aircraft manually where the standard operating procedure advises doing this in case of interference or malfunction.

Choice of approach type:

The commander shall consider all relevant factors in choosing the appropriate approach type. When it is appropriate and available a precision approach should be the preferred option. This is based on the fact that the vertical profile of an approach with an 'electronic' glide path is more 'straight forward' to follow and verify than the vertical profile of a non-precision approach.

Stabilised approach

Recommendation 3.4.18 The aircraft operator must publish Company Criteria for stabilised approaches in their Operation Manual. Flight crew should go-around if their aircraft does not meet the stabilised approach criteria at the stabilisation height or, if any of the stabilised approach criteria are not met between the stabilisation height and the landing. Company guidance and training must be provided to flight crew for both cases.

It's well accepted throughout the industry that a pre-requisite for a safe landing is a stabilised approach. This generally means:

- The aircraft is on the correct lateral and vertical flight path
- The aircraft is in the landing configuration
- Thrust and speed are stabilised at the approach value
- The landing checklist is completed.

All of these requirements need to be fulfilled at the stabilisation height in order for the flight crew to continue with the approach.

Although the stabilised approach principle is well accepted and known throughout the pilot community adherence to the principle is not always perfect. Flight crew are still continuing to land from un-stabilised approaches. How can aircraft operators improve the adherence of their flight crew to the stabilised approach principle?

- **Awareness campaign:** to improve the buy-in from flight crews, any new Standard Operating Procedure (SOP) should be introduced with a kind of awareness campaign to explain the philosophy behind this new SOP. Examples of incidents or accidents that could have been prevented with this SOP would certainly strengthen its case.

- **Standard Operating Procedure:** a well-defined SOP regarding the stabilised approach principle must be published in the company Operations Manual. This should include:
    - **Criteria of stabilised approach:** they must be clearly defined and easily assessable by the flight crew. Examples could be:
        - **Correct lateral and vertical flight path:** aircraft within +/- 1 dot vertical path and localiser.
        - **The aircraft is in the landing configuration:** no more changes to a different flap setting due to unexpected wind change in approach
        - **Thrust and speed are stabilised at the approach value:** thrust should be stabilised at its normal approach value or certainly above idle. Speed should be within certain limits of the final approach value (e.g. -5/+10 kt).Note that the use of an Auto Thrust System (ATS) for approach and landing can modify the previous recommendations. The Operator should also specify whether it is possible to use the ATS without autopilot for approach and landing. If it is possible, the Operator should promote the use of ATS in manual flying as it may reduce the pilot workload in monitoring the speed and adjusting the thrust therefore freeing mental capacity for situational awareness. This may also prevent aircraft carrying excess speed over the threshold; (see later)
        - **The landing checklist is completed:** This will allow the pilot flying to fully focus on his flying duties and the non-flying pilot to focus on his monitoring duties (see later)
    - **Definition of stabilisation height:** the following values are accepted throughout the industry: in VMC 500ft above the airfield elevation and 1000ft in IMC conditions. Note that some operators use only one value whatever the weather conditions are. This not only simplifies the operating procedures but also simplifies the verification process. (see later)
    - **Check of stabilised approach criteria at stabilisation height:** The most often reported reason is that the flight crew was not aware of being unstable at the stabilisation height. This could be prevented by a proper check at the stabilisation height, similar to a height check at the outer marker or DME fix. This check would preferably be initiated by an auto callout (e.g. "one thousand") by the aircraft system.
    - **Actions at stabilisation height:** When passing the stabilisation height, the PNF/PM makes the compliance check and calls out the result (for instance "stable" / "not-stable"); the PF has only the choice between two possibilities; continue the approach or discontinue it, using the appropriate call out i.e. "continue" or "go-around". In case the approach is not stabilised, the PF must initiate a go-around manoeuvre.
    - **Actions in case of de-stabilisation below stabilisation height:** while previous SOP protects against high energy or rushed approaches this SOP concerns destabilisation after passing the stabilisation height. Usually this is a transient condition often caused by changing wind velocity or direction. Provided the PF can rejoin the stabilised approach criteria the approach may continue. During the later stages of the flight (below 500ft) the PF's focus shifts from inside the flight deck to outside. He will start looking for the visual references he needs in order to continue the approach beyond the DH. Now the monitoring task of the PNF/PM becomes paramount

and he should call out any deviations from the stabilised approach criteria:

- Excessive Localiser or vertical path deviations;
- Excessive speed deviations
- Vertical speed greater than 1000ft/min
- Excessive pitch
- Excessive bank angle

The PF must acknowledge this call and make positive corrective actions. The question remains at which position must the aircraft ultimately have regained its stabilised criteria before a go-around must be initiated?

One scenario could be as the aircraft passes the threshold, just before the flare manoeuvre is initiated. Considering the complexity of the landing manoeuvre the PF is "task saturated" at this time and may not have the required capacity to make complex judgement calls e.g. to mitigate the risk of tail strike. Furthermore as he has "managed to come this far" he will not be very go-around minded anymore. The PNF who is performing the monitoring duties has the spare capacity and he should his use his judgement to assess the corrections made by the PF will be in time to allow for a safe landing. If he considers this it not the case he should call for a go-around which must be followed by the PF. This philosophy has consequences for the decision-making process and CRM; training is needed to enable the PNF/PM to consistently judge the situation and takes the proper decision on short final.

Flight crew must acquire the visual reference at the minima and maintain it. If at any time during an approach one of the flight crew members is not sure about the safe outcome of the landing a go-around must be initiated or called for. **It must be highlighted that this option remains available until the aeroplane touches the ground and up to the selection of reverse thrust.**

- **Verification of compliance:** this step is very important to indicate that compliance with this SOP is vital and non-negotiable. Verification can be made using means such as an FDM system and air safety report in line with ICAO Safety Management Systems practices. Due to the relationship between unstabilised approaches and landing accidents and incidents, it is in the interest of the flight crew to obtain a debriefing in accordance with the FDM protocol signed between management and pilots.
- **De briefing of results:** company publications should regularly include compliance levels and re-iterate the importance of compliance with the stabilised approach criteria. This should be continued until this principle is well established in the safety culture of the company.
    - **Actions in case of late loss of visual reference:** As evidenced by an event during a night time landing in 2008, visual references may be lost during the final phase of an approach even when sufficient visual contact with the runway was available at decision height. In this event, both pilots became visual with the runway between 300ft and 200ft, and at the decision height of 200ft had more than sufficient visual references to continue the approach. It was only when the aircraft descended through 20ft AGL during the flare that it entered an area of fog. Both pilots lost sight of the runway edge and runway lights became a glow illuminating the fog. At this point the PF made some inadvertent rudder inputs that caused the aircraft to drift sideways until one main gear left the paved surface. The crew initiated a go-around and after just 4 seconds of ground contact the aircraft was airborne again, although they were unaware that the main gear had rolled on unpaved ground. Minor damage was caused to the runway edge lighting and the main gear assembly. The low visibility had not been reported in the ATIS or by the tower. There was no runway centreline lighting, and runway edge lights were not installed as per ICAO Annex 14, too far from the runway edge, frosted and misaligned. This incident highlights the necessity for airport facilities to be in accordance with ICAO Annex 14 provisions, for the accurate and timely reporting of changes in the conditions, including RVR, and for the preparedness of pilots to perform a go-around when encountering significant loss of visual cues even late in the approach and up to deployment of the thrust reversers.
    - **Ref.** http://www.skybrary.aero/bookshelf/books/452.pdf

Go-around Decision Making

A primary opportunity to prevent a runway excursion is in the decision making of the pilot to go-around or continue a takeoff once at or approaching V1, however it is relatively uncommon for a flight crew to call for a go-around, in the order of 30% of go-around manoeuvres are called by Flight crew. Go-around is a normal but rarely performed procedure, statistics show that a flight crew member may perform a go-around during in-line flying only a few times a year. Training in the simulator to perform unprepared as well as prepared go-around manoeuvres should be done regularly using various scenarios.

GO-AROUND Policy and Pilot non flying duties

Recommendation 3.4.16 The aircraft operator must publish the company policy, procedure and guidance regarding the go-around decision. It should be clearly stated that a go-around should be initiated at any time the safe outcome of the landing is not assured. Appropriate training should be provided.

Recommendation 3.4.19 The aircraft operator should publish a standard operating procedure describing the pilot non flying duties of closely monitoring the flight parameters during the approach and landing. Any deviation from company stabilised approach criteria should be announced to the pilot flying using standard call outs.

Flight crew in commercial aviation have been traditionally trained and tested to execute a go-around when they lack the required visual references at the Decision Height (DH). While this offers good testing of the execution of the manoeuvre the involved decision making process is straight forward.

Numerous Incidents and Human Factors studies have revealed that once an individual has selected a particular course of action, it takes very compelling cues to alert them to the advisability of changing their plan (tunnel vision).

This is why the role of the pilot non-flying is so important. Not only his monitoring task is important, but he has more spare mental capacity and has a more "objective" view of the flight. If he's not confident with the safe outcome of the approach and landing he should call for a go-around. This would be a logical call if the pilot non-flying is the commander, but it could be a much more difficult call if it would be a first officer. The philosophy that either pilot can call for a go-around is vital and should be an important item in the company's CRM training. Especially low-experienced first officers should be trained to be assertive when faced with commanders refusing to take their suggestions on board or displaying tunnel vision.

To help flight crew in their decision management various check heights and calls have been introduced:

- The Outer Marker/ fixed distance check
- The stabilisation height
- 100 Above / approaching minimum
- Minimum

Compliance with all the flight parameter tolerance at one 'gate' means the flight can continue until the next 'gate' where again an assessment shall be made. It should be emphasised that the flight crew should not become complacent when a 'gate' is passed successfully. In fact they should be continuously prepared for a go-around until the 'point of no return' the selection of the reverse thrust. Aircraft Operators with aircraft without reverse thrust should define their own specific policy.

Training on go-arounds should be provided in the simulator and in the classroom. Very often crews are 'not aware' that they are flying an un-stabilised approach. Using real case studies helps to raise the understanding of the potential risk for a runway excursion after an un-stabilised approach.

Crews should not be allowed to fly un-stabilised approaches during their simulator training. During simulator training instructors should put the same emphasis on following the go-around procedures than in the real world.

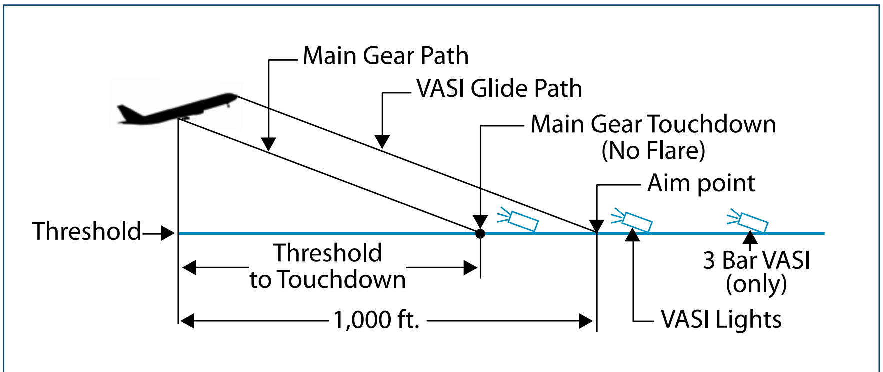
Flight crews are traditionally trained to perform a go-around at minima and this procedure is well mastered by most pilots. However, most of the go-arounds do not happen at minima. It is thus important to include different go-around scenarios into the training.

An open reporting culture in the scope of an SMS will help to identify precursors to 'wrong' decision making. De-identified incidents should be used as examples during recurrent training. This helps to show that incidents/accidents do not only happen to the others. An open policy on go-arounds shall be implemented, making go-around a normal procedure and not an abnormal issue.

Where do we land?

Recommendation 3.4.21 The aircraft operator should publish the standard operating procedure regarding a touchdown within the appropriate touchdown zone and ensure appropriate training is provided.

While still in IMC conditions flight crew are expected to follow the localiser and glide slope indications. When transitioning to VMC conditions the PF is gradually shifting his or her attention to the visual approach indicator or to the runway and the touchdown point; still using their instruments as a backup.



The PAPI or VASI provides visual descent guidance information during the approach. They are visual projections of the approach path normally aligned to intersect the runway at a point 1,000 or 1,800 feet beyond the threshold. Flying the PAPI or VASI glide slope to touchdown is the same as selecting a visual aim point on the runway adjacent to the VASI installation.

737-600 - 737-900ER

737 MODEL	FLAPS 30		MAIN GEAR OVER THRESHOLD		THRESHOLD TO MAIN GEAR TOUCHDOWN POINT-NO FLARE (FEET)
	VISUAL GLIDE PATH (DEGREE)	AIRPLANE BODY ATTITUDE (DEGREES)	PILOT EYE HEIGHT (FEET)	MAIN GEARHEIGHT (FEET)	
-600	3.0	3.7	50	36	657
-700	3.0	3.7	50	34	647
-800	3.0	2.4/3.6	49/50	34/33	651/633
-900	3.0	1.6	49	35	659
-900ER	3.0	2.6	49	34	641

The position of the runway and the touchdown point on the windshield are very important and should become a 'reference value' for the pilot. Any deviation from the approach profile should be recognised by the pilot and corrections made.

Visual aim points versus gear touchdown point differences increase as glide path angle decreases as in a flat approach. For a particular visual approach, the difference between gear path and eye level path must be accounted for by the pilot.

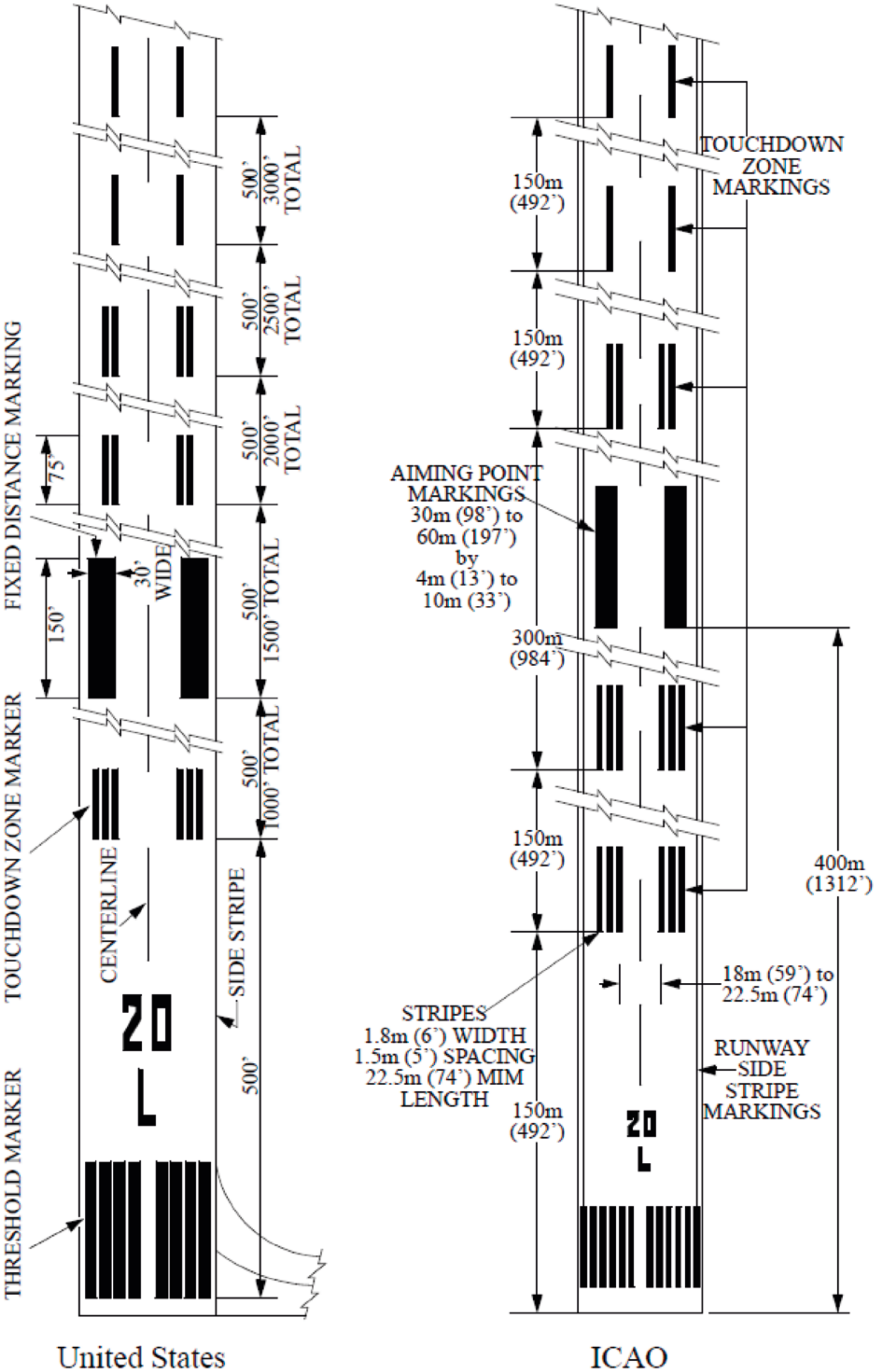
Systematically making long landings or steep approaches would mean different positions of the landing runway on the windshield and dilute the value of this visual reference as a backup for profile deviations.

Being stabilised on the profile and having the runway in sight, pilots can already make a projection of where their flight path will intersect with the runway; this projected visual touchdown point should be the Aiming Point Marking normally resulting in the Main Landing Gear touching down on the second touchdown marker which is at 300 metres. This technique ensures that the landing complies with the assumptions made by the performance calculations: stabilised 3° profile, appropriate threshold crossing height (TCH), and approach speed.

Crews should be made aware of the different existing touchdown zone markings during their initial and recurrent training. Initial and recurrent training should include special or unusual operational requirements at specific airports in the company's network (e.g. downdrafts/updrafts due terrain, shifting winds, and visual illusion induced by narrow/wide runway or night operations).

Aircraft Operators must publish a Standard Operating Procedure on the area where the touch down must be achieved or a balked landing must be initiated. This could be the touch down zone (first 1000m) or 1/3rd of the runway, whichever is less.

Training on the use of the Head Up Guidance System, if installed, should be made during ground courses to assure landing within the appropriate touchdown zone, with practical training being conducted during simulator sessions.


FIXED DISTANCE MARKING
TOUCHDOWN ZONE MARKER
THRESHOLD MARKER
CENTERLINE
SIDE STRIPE
75'
150'
30' WIDE
500' 3000' TOTAL
500' 2500' TOTAL
500' 2000' TOTAL
500' 1500' TOTAL
500' 1000' TOTAL
500'
20 L
United States
TOUCHDOWN ZONE MARKINGS
150m (492')
150m (492')
AIMING POINT MARKINGS 30m (98') to 60m (197') by 4m (13') to 10m (33')
300m (984')
150m (492')
400m (1312')
18m (59') to 22.5m (74')
STRIPES 1.8m (6') WIDTH 1.5m (5') SPACING 22.5m (74') MIM LENGTH
RUNWAY SIDE STRIPE MARKINGS
150m (492')
20 L
ICAO

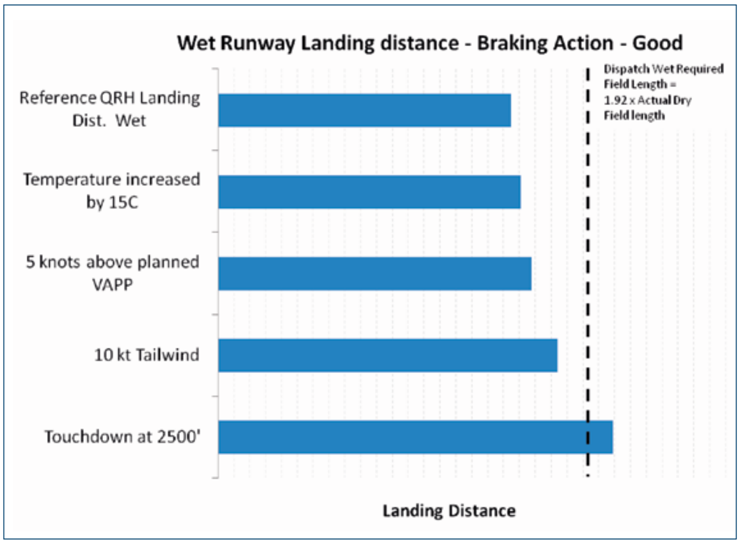
Landing Performance

The parameters affecting the landing distance are published in the Flight Operations Manual. Flight crew should have a good understanding of the sensitivity of the landing distance to these parameters in order to make sound go-around decisions. The following data shows the effect of relatively minor deviations from a baseline calculation of landing distance for a wet runway. The reference condition is a reasonably attainable performance level following normal operational practices on a nominal wet runway surface. The reference QRH data on the bar chart below is based on:

- 1500 foot touchdown
- VAPP=VREF+5, 5 knot speed bleed off to touchdown
- Sea Level, Standard Day (15 C)
- No wind, no slope
- Recommended all engine reverse thrust
- Braking Action – Good, consistent with FAA wheel braking definition of a wet non-grooved runway.

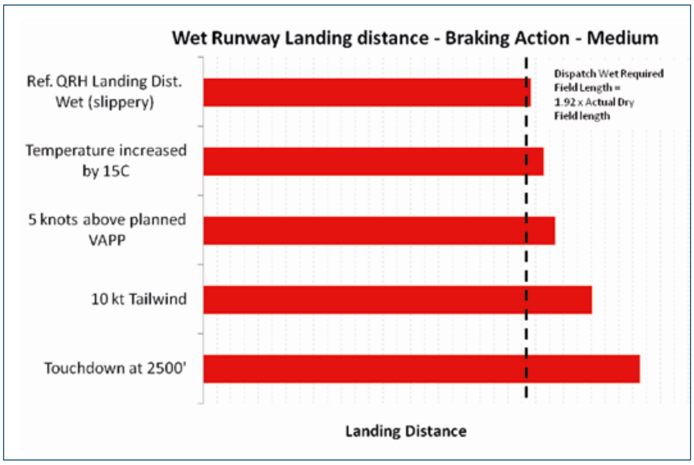
The vertical line represents the dispatch requirement that is 1.92 times the dry runway capability of the aeroplane.

Each bar as you go down the chart demonstrates the cumulative effect of the operational variation listed. In overrun incidents, you usually see a number of factors that contribute to using up the margin available, especially if the runway has worse wet runway friction capability.



It can be seen from this graphic that in general the dispatch landing distance is conservative enough to absorb some deviation from the expected conditions. However, when enough deviations from the reference conditions come together the dispatch landing distance or actual runway available may not be adequate.

Wheel braking may be reduced on the wet runway because of questionable runway condition due to rubber build up, polishing, or puddling due to heavy rain or poor drainage. The following chart shows the same information as above, but assuming a Braking Action Medium runway which is consistent with data that has been seen in some overrun accidents and incidents where the runway's maintenance condition is in question.



You can see from the chart above if the runway is a questionable wet runway you can very quickly use up the entire margin in the dispatch wet runway calculation.

The landing phase being very complex does not leave much mental capacity to make complex instantaneous calculations; so basic rules of thumb must be used. Fully automated system will provide instantaneous information to the pilots therefore improving their decision making. However it is very important for the flight crew to get the aeroplane on the ground at the right point and at the right speed to ensure there is the greatest amount of distance remaining to absorb things the pilot does not have control over such as unreported tailwind or late wind shifts from cross to tail or worse than expected runway friction capability, etc.

Use of all stopping devices

Recommendation 3.4.23 The aircraft operator should publish the Company Policy regarding the appropriate use of all stopping devices after landing and ensure appropriate training is provided.

Recommendation 3.4.24 Flight crew should use full reverse on wet/contaminated runways irrespective of any noise related restriction on their use unless this causes controllability issues. It is important that the application of all stopping devices including reverse thrust is made immediately after touchdown without any delay.

Ground Spoilers/Speed brakes:

Ground Spoilers primarily reduce the lift and increase the drag. Reducing the lift increases the weight on the wheels thus improves the brake performance. The effect of the ground spoilers is even greater on wet or contaminated runway where brake performance is already less, and risk of aquaplaning is increased.

Ground spoilers are usually automatically extended, and their automatic extension should be monitored by the pilot non-flying. If they do not extend, a call out should be made and where possible, they should be extended manually without delay.

Reverse thrust:

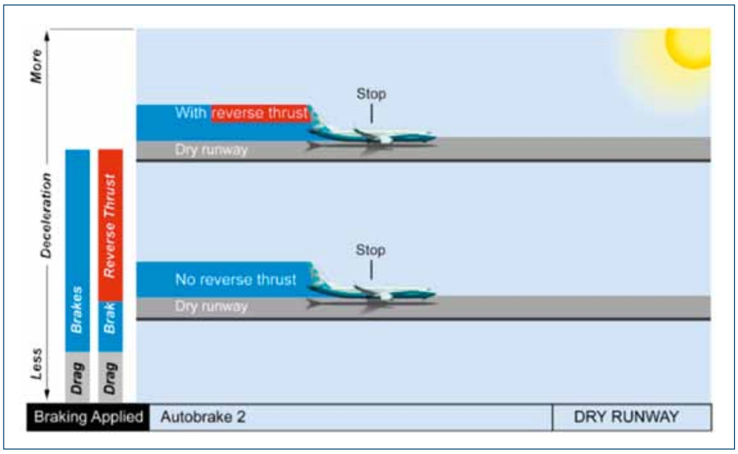
The deceleration effect of thrust reversers is more effective at high speed, so the selection should be done as soon as possible, generally at main landing gear touchdown. The reverse thrust should be maintained until the stop is assured.

It is also important to understand that if the reverser is stowed early, the reapplication of reverse thrust from forward idle can take up to 10-15 seconds to reach effective reverse thrust level (depending on the aircraft type); however, the reapplication from reverse idle will take only 3-5 seconds to reach an effective reverse thrust level.

Like the ground spoiler extension selection of the reverse thrust should be monitored by the pilot non-flying.

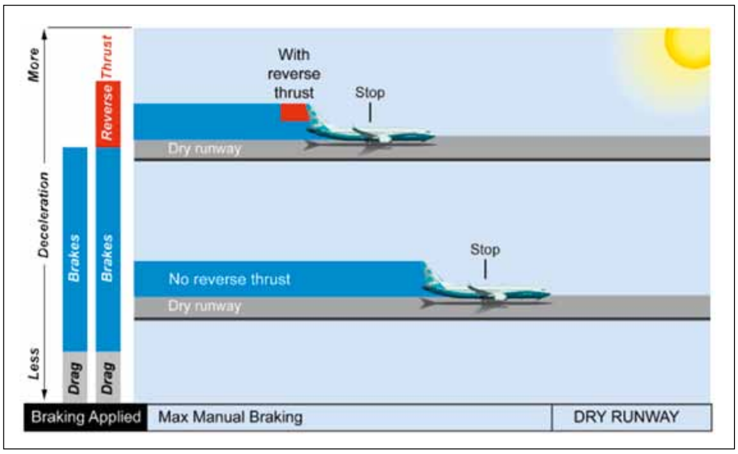
Brakes/Auto brake:

Selecting an auto brake level means selecting a deceleration rate rather than a braking effort. Selecting reverse thrust with an auto brake level will not increase the deceleration effort on a dry runway, assuming ground spoilers/speed brakes are extended; it will simply reduce the energy applied to the brakes. On slippery runways, the target deceleration associated with the selected autobrake level may not be achievable with braking alone, in which case reverse thrust use is essential for stopping the aircraft even with autobrake.



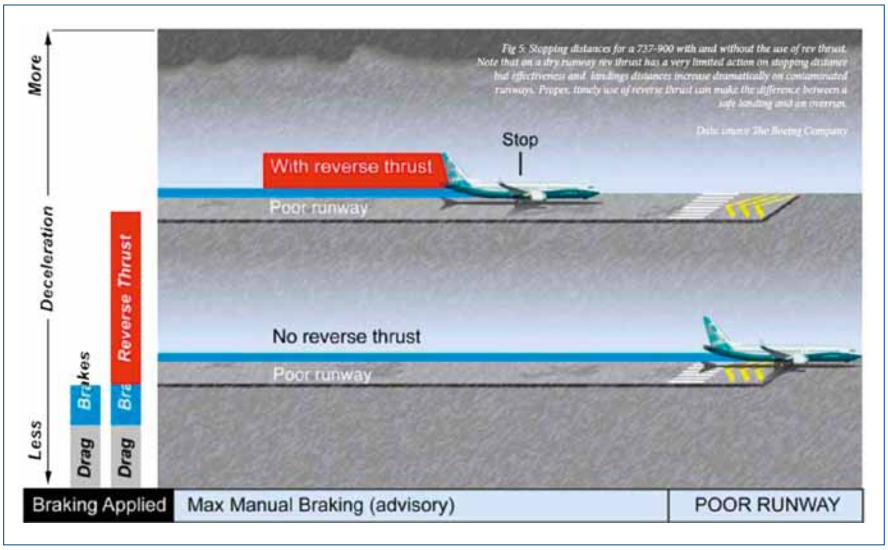
Impact on brake engery using rev thrust with autobrakes
Data source: The Boeing Company

Selecting reverse thrust on a dry runway provides minimal additional deceleration with maximum manual braking and no additional deceleration with auto brakes.



Ratio of stopping forces
Data source: The Boeing Company

However, when landing on a runway with poor braking action, the effect of reverse thrust can make a dramatic difference. The next figure shows when using max manual braking, thrust reversers are additive. The figure shows that the deceleration due to drag has remained the same for all runway conditions, but the deceleration from reverse thrust has increased significantly while brake efficiency has decreased due to slippery runway conditions.



It is important to use full reverse on a wet/contaminated runway irrespective of any noise or environmental restrictions.

Bounced Landing Recovery

Recommendation 3.4.26 The aircraft operator should include specific recovery techniques from hard and bounced landings in their training program.

Bouncing at landing usually is the result of one or a combination of the following factors:

- Excessive sink rate
- Late flare initiation
- Power-on touchdown
- Wind shear or thermal activity
- Etc.

Aircraft Operators should make sure their SOP include the required techniques for bounce recovery. This recovery technique should also be included in the initial and recurrent training, especially for training captains.

In case of a light bounce a typical recovery technique would require the pilot to maintain the pitch attitude (any increase could cause a tail strike) and allow the aircraft to land again. Special attention should be paid to the increased landing distance. If the remaining runway length is not sufficient a rejected landing can still be initiated until the selection of the reverse thrust.

In case of a high bounce, a landing should not be attempted as the remaining runway length might not be sufficient to stop the aircraft. A rejected landing initiated from this position would typically require the pilot to apply Takeoff go-around (TOGA) thrust and maintain the pitch attitude and configuration until the risk for a tail strike or second touchdown has disappeared. Then the normal go-around technique can be used.

Once a rejected landing is initiated, the flight crew must be committed to proceed and not retard the thrust levers in an ultimate decision to complete the landing. On one occasion the commander took control and initiated a go-around after his first officer inadvertently made a bounced landing. After the go-around initiation the aircraft touched the runway again triggering the takeoff configuration warning. This activation was not expected by the commander and made him change his mind to stop the aircraft. This resulted in the aircraft coming to a stop very close to the end of, in this case, a very long runway.

Runway excursions, impact with obstructions and major aircraft damage are often the consequence of reversing an already initiated rejected landing.

Landing Long

Recommendation 3.4.27 In cases where an aircraft operator accepts landing long as a practice, the practice should be safety risk assessed, with a published policy and standard operating procedure supported by appropriate flight crew training.

It was mentioned earlier that long landings or steep approaches would mean different positions of the landing runway on the windshield and dilute the value of this visual reference as a backup for profile deviations. If an aircraft operator accepts this practice, it should be safety risk assessed. A standard operating procedure should be published and adequate training provided.

References:

Airbus: Flight Crew Training Manual (FCTM)
Airbus Flight Crew Operations Manual (FCOM)

Airbus: Getting to grips with aircraft performance
Airbus: Flight Operations Briefing Notes: Flying Stabilised Approaches
Airbus: Flight Operations Briefing Notes: Bounce Recovery – Rejected Landing

Australian Transport Safety Bureau: Tail strike and runway overrun Melbourne Airport, Victoria 2009

Transportation Safety Board of Canada: Runway Overrun and Fire Toronto 2005.

Joint industry/FAA Takeoff Safety Training Aid

BOEING: Flight Crew Training Manual (FCTM)
IFALPA / BOEING: Briefing leaflet: Certified versus advisory landing data on Boeing aircraft.

JAR/EASA Flight Crew Licensing

Flight Safety Foundation: ALAR tool kit

EUROCONTROL: A study of runway Excursion from a European Perspective

IATA: Runway Excursion Case Studies; Threat and Error Management Framework