VALIDATED BY

COORDINATED BY

Global Action Plan for the Prevention of Runway Excursions

Part 1 - Recommendations
Part 2 - Guidance and Explanatory Material

Organisations that supported the initiative

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STATEMENT OF COMMITMENT

Notwithstanding specific aviation risks in 2020 associated with the COVID-19 pandemic, the rate and number of runway excursions worldwide remained steady in the last decade. Data show the industry has reduced the rate of commercial aviation runway excursion accidents, but the absolute number of accidents and incidents and their severity still indicate a very high risk.

In a study of incident and accident data dedicated to this action plan process, the International Air Transport Association (IATA) reported that between 2005 and the first half of 2019, 23 percent (283) of accidents in IATA's global accident database involved a runway excursion. This was the most frequent end state, followed by gear-up landing/gear collapse (15 percent) and ground damage (12 percent).

Managing the runway excursion risk is one of the best examples of how different aviation segments cannot achieve success alone. Runway excursion risk and resilience management rely on a system of tightly coupled factors for success, and that system depends on a joint and coordinated effort of all the aviation players. The complexity of runway excursion prevention comes also from the fact that the effect of the risk and resilience factors is highly cumulative — runway condition maintenance and reporting, aircraft performance and operations, collaborative approach path management and adherence to robust policies for safe descent and approach planning, stabilised approach, safe landing and go-around are some examples.

The jointly owned risk requires joint solutions. This is why the industry came together, within a dedicated working group, to discuss and agree on the most important actions to address the runway excursion risk. The result is a list of recommendations that represent the industry consensus on the best practices and intervention beyond simple regulatory compliance. The recommendations are mainly generic, and it will be up to the responsible organisations to decide specific details for possible implementation, after taking local conditions and specific context into account.

Addressing both the risk and the resilience factors has been a guiding principle of the working group that reviewed accident and incident data, single scenarios and best practices, and suggestions on risk and resilience management.

The recommendations are the result of the combined and sustained efforts of organisations representing all segments of aviation. The organisations that contributed to this action plan are committed to enhancing the safety of runway operations by advocating the implementation of the recommendations that it contains. These organisations include, but are not limited to, aerodrome operators, air navigation service providers, aircraft operators, aircraft manufacturers, R&D organisations, regulators, international organisations and associations.

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INTRODUCTION AND BACKGROUND

This document contains Part 1 and Part 2 of the Global Action Plan for the Prevention of Runway Excursions (GAPPRE).

Part I contains the agreed recommendations to the following civil aviation organisations: aerodrome operators, air navigation service providers (ANSPs), aircraft operators, aircraft manufacturers, regulators, the International Civil Aviation Organization (ICAO) and addressees of the research and development (R&D) recommendations (States, international organisations and the industry).

Part 2 provides explanatory and guidance material, and related best practices for the recommendations listed in this document. The guidance and explanatory material (GEM) are provided as appendixes to this document.

The recommendations and the (GEM)were developed by six dedicated working groups and were extensively reviewed and validated by:

- Airports Council International — World (ACI World);
- The Civil Air Navigation Services Organisation (CANSO);
- The European Union Aviation Safety Agency (EAA); and,
- The International Air Transport Association (IATA).

The development of the GAPPRE recommendations is based on the following principles:

- Provide recommendations that address actions beyond regulatory compliance — the recommendations in this action plan are not exhaustive in managing the runway excursion risk and resilience. It is fundamental that organisations shall be compliant to international, regional and national rules and regulations.
- Base recommendations on consensus — a recommendation is included in the action plan only if there was a consensus for it during the drafting and the subsequent validation process.
- Embrace further data analytics — suggest to actors that they make better use of existing data and fuse and analyse larger volumes of heterogeneous data.
- Address both longitudinal and lateral runway excursions.
- Include runway excursion mitigations.
- Promote technology embedded in systemic solutions — promote technological solutions that are clearly integrated with the respective training, procedures, standardisation, certification and oversight.
- Provide R&D recommendations for issues with clear potential high-risk mitigation benefits but without the maturity to be implemented within the next 10 years.
- Promote a set of selected proven efficient solutions, which are not yet standard (still not used by all actors) but that have been proven to be efficient in reducing the risk of runway excursions, based on data analysis and lessons learnt.
- Provide functional recommendations — leave the design of specific implementation solutions to the industry.
- The verb “should” is used to signify that, while a recommendation does not have the force of a mandatory provision, its content has to be appropriately transposed at the local level to ensure its implementation.

The development of the GEM is based on the following principles:

- Provide further context to the targeted audience in order to facilitate the implementation of the recommendations contained in Part 1.
- Provide explanation, wherever possible, of the recommendation drivers.
- Incorporate advice for both normal and non-normal operation within the GEM targeted at the operational actors.
- Use the principles of conservatism and defence in depth.
- Address organisations such as aircraft operators, airports and ANSPs rather than individuals like pilots and air traffic controllers.

The GEM content should not be seen as limiting or prescriptive. It is based on best practices and materials shared by the industry in support for GAPPRE implementation. The boundaries set by national regulators and internationally accepted provisions should be respected.

The GEM will be continually updated and made available through the safety knowledge management process of SKYbrary (*www.skybrary.aero*).

The organisations to which this action plan is addressed should:

- Organise a review of the respective recommendations and assess their relevance against their local conditions and specific context.
- Consult the best practices for implementing the selected recommendations and seek support, if needed, from the GAPPRE coordinating partners.
- Conduct an appropriate impact assessment (including safety assessment) when deciding on the specific action to implement the recommendations.
- Implement the specific action/change and monitor its effectiveness.
- Share the lessons learnt with the industry.

GLOBAL ACTION PLAN FOR THE PREVENTION OF RUNWAY EXCURSIONS PART 1

RECOMMENDATIONS

RECOMMENDATIONS TO AERODROME OPERATORS

REF	Recommendation	Action by	Implementation Date
ADR1	Ensure that runways are constructed, resurfaced and repaired in accordance with the national or regional (e.g. EASA) regulations, so that effective friction levels and drainage are achieved.	Aerodrome Operator	**Ongoing**
ADR2	An appropriate program should be effectively implemented to ensure the removal of contaminants from the runway surface as rapidly and completely as possible to minimize accumulation and preserve friction characteristics.	Aerodrome Operator	**End of 2023**
ADR3	If provided, ensure that approach radio navigation aids (e.g. ILS) and visual aids (e.g. AGL, PAPIs and surface markings) are maintained in accordance with ICAO Standards and Recommended Practices. An appropriate method for the inspection and assessment of markings deterioration should be implemented.	Aerodrome Operator	**End of 2023**
ADR4	Ensure that the runway holding positions are clearly marked, signed and if required, lit. If intersection takeoffs are conducted, install at the relevant runway holding positions signs to indicate the Takeoff Run Available (TORA).	Aerodrome Operator	**End of 2023**
ADR5	Ensure robust procedures are in place for calculating temporary reduced declared distances e.g. due to work in progress on the runway. When reduced declared distances are in operation, ensure that the temporary markings, lighting and signs accurately portray the reduced distances and that they are well communicated in a timely manner to the state's aeronautical information services for publication and to the relevant ATS units.	Aerodrome Operator	**End of 2023**
ADR6	Ensure that the procedures to assess runway surface conditions according to ICAO Global Reporting Format include reactive as well as proactive surface assessment to make sure hazardous changes are all identified and communicated in a timely manner.	Aerodrome Operator	**End of 2021**
ADR7	Ensure robust procedures are in place for communicating information regarding changing surface conditions as frequently as practicable to the appropriate services according to the ICAO Global Reporting Format. Roles, responsibilities of stakeholders and coordination procedures should be formalised.	Aerodrome Operator	**End of 2021**
ADR8	In accordance with ICAO standards (and regional, e.g. EASA regulations), wind sensors and wind direction indicators (wind socks) should be sited to give the best practicable indication of conditions along the runway and touchdown zones.	Aerodrome Operator	**End of 2025**
ADR9	Consider equipping for digital transmission of ATIS as appropriate to ensure that ATIS information is updated in a timely manner.	Aerodrome Operator.	**End of 2025**

REF	Recommendation	Action by	Implementation Date
ADR10	If installed, RWY centreline lights should also be used together with the runway edge lights whenever runway edge lights are switched on and when the runway is in use.	Aerodrome Operator	**End of 2023**
ADR11	Ensure appropriate coordination with the meteorological service provider, the ANSP and the aircraft operators to regularly assess the relevancy of weather data, in particular at large aerodromes where there could be spatial differences in weather data.	Aerodrome Operator	**End of 2023**
ADR12	Ensure runway exits are appropriately named according to a logic of succession of numbers and letters avoiding possible ambiguity.	Aerodrome Operator	**End of 2025**
ADR13	Runway surroundings should be considered when designing or modifying strips or RESA. It is necessary to consider the local constraints against ICAO provisions and regional (e.g. EASA) regulations so as to ensure relevant mitigation.	Aerodrome Operator	**Ongoing**
ADR14	Information related to air operations hazard or specificities in the airport vicinity should be identified and addressed to pilots in the Local Runway Safety Team (LRST) and published through an appropriate means.	Aerodrome Operator	**End of 2023**
ADR15	Runway condition codes assessed should be compared against braking action reports by the pilots to ensure the accuracy of the information provided to the pilots.	Aerodrome Operator	**End of 2023**
ADR16	Consider using Approach Path Management (APM) in coordination with local ATC and aircraft operators. Associated issues should be addressed by the LRST.	Aerodrome Operator	**End of 2023**

RECOMMENDATIONS TO AIR NAVIGATION SERVICE PROVIDERS

REF	Recommendation	Action by	Implementation Date
ANSP1	ANSPs should ensure the importance of stabilised approach, its elements and compliance with final approach procedures and aircraft energy management are included in initial and refresher training of ATCOs conducted by ANSPs and ATCO Training Organisations, as well as in AFISOs training, as applicable.	Air Navigation Service Provider	**End of 2023**
ANSP2	With regard to assignment of or change to runway assignment for arriving or departing traffic: ANSP2 a. Whenever the runway change is pre-planned, notify it as early as practicable together with the expected time of the change to flight crews, including by adding relevant information in ATIS, where available. ANSP2 b. As far as practicable, avoid changing the assigned runway to aircraft on approach or taxiing for departure. ANSP2 c. ANSPs should ensure ATCOs are aware that RWY changes create additional workload, increase vulnerability to error and flight crews need time to re-brief and prepare for it. ANSP2 d. ANSPs should ensure that the runway configuration change procedure/process takes account of the above points and of the tailwind information as appropriate. ANSP2 e. When operationally possible, accept the flight crew preference for a runway when requested "due to performance limitations".	Air Navigation Service Provider	**End of 2023**
ANSP3	ANSPS should: ANSP3 a. Review available data (e.g. occurrence reports, go-around / missed approach data etc.) with the aim of identifying the ANSP-related runway excursion contributing factors and relevant mitigations, for example enhanced airspace design and procedures and ATCO training and procedures. ANSP3 b. Share at network level the identified runway excursion contributing factors and relevant mitigations.	Air Navigation Service Provider	**End of 2023**
ANSP4	Review processes covering the provision of essential information on aerodrome conditions such as weather, wind and runway surface conditions (e.g. when 'wet' or contaminated) to ensure: ANSP4 a. A consistent, timely and accurate broadcast of aerodrome information. ANSP4 b. The integrity of the essential information supply chain from the originator (e.g. Met Office/Aerodrome Operator) to the user (e.g. flight crews, ATS, Met Office, aerodrome operator and AIS provider). ANSP4 c. Training on the use of ATIS/D-ATIS is provided to relevant operational staff. ANSP4 d. Compliance with the ICAO Global Reporting Format for runway surface conditions assessment and reporting, including the training of the relevant ANSP personnel.	Air Navigation Service Provider	**End of 2021**

REF	Recommendation	Action by	Implementation Date
ANSP5	ANSP5 a. ANSPs should ensure that flight crews are informed of the Takeoff Run Available (TORA) or the Landing Distance Available (LDA) if these differ from the published data using appropriate means. The information should include any alternative runways which may be available. ANSP5 b. ATS providers should collaborate with the aerodrome operators to determine the runway entries from which intersection takeoffs may be performed, and develop coordinated procedures for such operations.	Air Navigation Service Provider	**End of 2023**
ANSP6	Participate in runway excursion safety information sharing at network level to facilitate, using just culture principles, the free exchange of relevant information on actual and potential safety deficiencies.	Air Navigation Service Provider	**End of 2023**
ANSP7	If installed, RWY centreline lights should also be used together with the runway edge lights whenever runway edge lights are switched on and when the runway is in use.	Air Navigation Service Provider	**End of 2023**
ANSP8	Consider equipping for digital transmission of ATIS, as appropriate (e.g. via telephone or other means).	Air Navigation Service Provider	**End of 2025**

RECOMMENDATIONS TO AIRCRAFT OPERATORS

REF	Recommendation	Action by	Implementation Date
OPS1	Aircraft operators should participate in safety information sharing networks with all relevant stakeholders. This should facilitate the free exchange of relevant runway safety information including identified risks, safety trends and good practices.	Aircraft Operator	**Ongoing**
OPS2	Aircraft operators should include and monitor aircraft parameters related to potential runway excursions in their Flight Data Monitoring (FDM) programme. Whenever standardised FDM markers are provided by the industry, aircraft operators should use them with priority to ensure the effectiveness of risk mitigation and safety assurance associated with runway excursion barriers and to allow comparability on an industry level.	Aircraft Operator	**End of 2023**
OPS3	Aircraft operators and training providers should include realistic, evidence- and competency-based scenarios into their training programmes requiring threat and error management for runway excursion prevention during both takeoff and landing. This should include evidence- and competency-based recurrent simulator training programmes which are representative in terms of environmental conditions, including crosswind, landing on contaminated/slippery runways and poor visibility adapted with simulator representativeness. Representativeness of simulators should be assessed and their limitations communicated (in order to avoid negative training)	Aircraft Operator	**End of 2023**
OPS4	Aircraft operators should incorporate appropriate technical solutions to reduce runway excursion risks, where available (including Runway Overrun Awareness and Alerting System (ROAAS), and runway veer off awareness and alerting systems, when and if available). If technical solutions are not available, operators should implement appropriate SOPs and TEM strategies which support flight crews in effectively preventing runway excursions.	Aircraft Operator	**End of 2027**
OPS5	If technically feasible, aircraft operators should equip their aircraft fleet with data-link systems (e.g. ACARS) enabling them to digitally obtain the latest weather information (e.g. D-ATIS or METAR). The use of this technical means has to be supported by adequate SOPs enabling all pilots on the flight deck to familiarise themselves with the latest weather conditions without impeding aircraft and flight path monitoring.	Aircraft Operator	**End of 2025**
OPS6	Aircraft operators should implement policies for flight crews not to accept ATC procedures and clearances which have the potential to decrease safety margins to an unacceptable level for the flight crew thereby increasing the risk of runway excursions. This includes such procedures and clearances which increase the likelihood of having an unsafe approach path management with consequences for safe landing, e.g. which bear the risk of being unstabilised at the landing gate or high-energy approaches.	Aircraft Operator	**End of 2027**

REF	Recommendation	Action by	Implementation Date
	These policies should be further supplemented by the implementation of effective SOPs and flight crew training. Flight Crews should be required to report such risks within their operators SMS and the aircraft operator should further report such risks to the ANSPs via established reporting systems. (see OPS1)		
OPS7	Aircraft operators should implement policies for safe descent and approach planning, stabilised approach, safe landing and go-around and should ensure that these are implemented in their training. Aircraft operators should define which elements of these policies have to be included and highlighted during the approach briefings by flight crews.	Aircraft Operator	**End of 2023**
OPS8	Aircraft operators should implement policies or SOPs for flight crews not to conduct takeoff or approach following any runway change until the appropriate set-up, planning, performance calculations (for multi-pilot operations this includes independent calculations and cross-checks by at least two pilots) and re-briefings are completed. When a takeoff runway change is received whilst taxiing, the above should be performed by flight crew without rushing and when the aircraft is stationary. Runway-excursion related TEM should be addressed in the briefing every time a runway change is expected, probable or actually occurs.	Aircraft Operator	**End of 2023**
OPS9	Aircraft operators should implement policies or SOPs for flight crews to request a more favourable runway for takeoff or landing for any reason, which may affect the safety of the flight and to advise the safety reasons to ATC.	Aircraft Operator	**End of 2023**
OPS10	Aircraft operators should implement policies or SOPs requiring flight crews to confirm prior to commencing the takeoff or landing phase that the actual conditions (weather and aircraft configuration) are better or at least correspond to the values used for performance calculations. When conditions are predicted to approach operational limitations, flight crews should be required to identify the limiting parameters and incorporate this into their TEM briefing.	Aircraft Operator	**End of 2023**
OPS11	Aircraft operators should define company cross- and tailwind limits which are specific to each type of aircraft operated. Moreover, specific guidance on the runway conditions and the gust components should be clarified. Aircraft operators should establish clear policies to allow their flight crews to reduce the established limits whenever deemed necessary for safety reasons in actual flight operation.	Aircraft Operator	**End of 2023**

REF	Recommendation	Action by	Implementation Date
OPS12	Aircraft operators should publish specific guidance and training for their flight crews on crosswind takeoff and landing techniques, especially in wet, slippery or contaminated runway conditions. This should include the correct touchdown and stopping techniques, which incorporate all available control and deceleration devices as well as TEM topics and methods for effective monitoring and intervention by the PM. Aircraft manufacturers advice should be incorporated, if available.	Aircraft Operator	**End of 2023**
OPS13	OPS13 a. Aircraft operators should ensure their policies or SOPs require flight crews to perform independent performance calculations. This should also include independent cross-checks of the load and trim sheet and the actual TORA/TODA from the AIS (e.g. if reduced by NOTAM) with TORA/TODA used to calculate the takeoff performance. This independent calculation should also be applied following a runway change. OPS13 b. Aircraft operators should ensure their policies or SOPs include flight crew gross-error checks and crew cross-checks prior to any data input and prior to executing any data input in the FMS.	Aircraft Operator	**End of 2023**
OPS14	Aircraft operators should publish SOPs and guidance which incorporate runway excursion mitigation associated with rejected takeoff decision making and rejected takeoff manoeuvres. Appropriate training should be provided.	Aircraft Operator	**End of 2023**
OPS15	Aircraft operators should develop SOPs which include an assessment, possibly prior to the top of descent, of landing performance based upon latest and best-available weather information. This calculation should not be performed using dispatch weather information. Flight crews should be informed of the type of landing distance data available (factored or unfactored) and of which correlating safety factors are used. When possible, the crew should complete descent, approach, landing planning, set-up and briefings prior to the top-of-descent.	Aircraft Operator	**End of 2023**
OPS16	Aircraft operators should develop a clear go-around policy which should be further supplemented by a set of SOPs and guidance materials to put this policy into action. This go-around policy should enable every flight crew member on the flight deck to call for a go-around at any time unless an emergency situation dictates otherwise. In all cases, the SOPs should require both pilots to have and retain the required visual reference below DA/MDA with a go around call mandatory if either pilot loses it. A go-around should also be mandatory if the approach becomes unstabilised below the specified approach/landing gate. Recurrent simulator training should be provided on the competencies of safe go-around in various stages during the approach and landing, including shortly prior or during touchdown (before activation of thrust reversers).	Aircraft Operator	**End of 2023**

REF	Recommendation	Action by	Implementation Date
OPS17	Aircraft operators should require the flight crew to carefully evaluate operational safety before selecting/accepting an approach and landing runway including the following: weather conditions (in particular cross and tailwind), runway condition (dry, wet or contaminated/slippery), inoperable equipment and aircraft and flight crew performance in order to reduce runway excursion risks.	Aircraft Operator	**End of 2023**
OPS18	Aircraft operators should clearly define stabilised approach, landing and go-around polices in their operations manual. These polices have to be aligned with regulations requirements and manufacturers guidance. Supplementing SOPs should include the requirement for completion of the landing checklist and flying with the final approach speed latest at the defined approach/landing gate. These SOPs should include appropriate means for the pilot monitoring (PM) to effectively monitor and, if needed, intervene. To properly implement the defined policies and SOPs, aircraft operators have to deliver appropriate training.	Aircraft Operator	**End of 2023**
OPS19	Aircraft operators should publish SOPs and guidance and provide training highlighting the importance of active monitoring and effective intervention by the pilot monitoring (PM) during descent, approach, approach path management and landing. Actions to be taken by the PM and required reactions by the PF should be clearly documented in the official publication (e.g. SOPs or Operations Manual, FCOM, etc). These publications should include guidance how to achieve effective PM performance, independent of rank and experience.	Aircraft Operator	**End of 2023**
OPS20	Aircraft operators should publish SOPs and guidance for their pilots not to conduct auto-land approach manoeuvres at airports when low visibility procedures (LVP) are not in force, unless: • the ILS critical and sensitive areas are protected, • ATC had been informed and reassurance of ILS sensitive area protection had been received or • specific precautions have been taken and risk analysis has been performed. More information is available in the guidance material. or • the aircraft is demonstrated as robust to non-protection of ILS sensitive area.	Aircraft Operator	**End of 2023**

REF	Recommendation	Action by	Implementation Date
OPS21	Aircraft operators should clearly define their policy for a safe landing and publish it in their SOPs and Operations Manuals. This policy should clearly define acceptable touchdown limits and prohibit intentional long and short landings, e.g. to minimise runway occupancy or minimise taxi time to the gate. The supplementing SOPs and guidance should include means, methods and responsibilities with regard to how a crew will identify and act on such limits. Appropriate classroom and simulator training should be provided.	Aircraft Operator	**End of 2023**
OPS22	Aircraft operators should publish SOPs and guidance for landing techniques that are aligned with ICAO Global Reporting Format and manufacturer's guidance for all runway states and environmental conditions. Aircraft operators should require their flight crew to always favour a go-around or diversion rather than to attempt a landing when approaching wet, slippery/contaminated runways without appropriate stopping margin and/or in limiting wind situations. Appropriate training should be provided including training in the ICAO Global Reporting Format.	Aircraft Operator	**End of 2021**
OPS23	Aircraft operators should publish SOPs for their flight crews when runway conditions are uncertain or actual or anticipated slippery wet, slippery or contaminated, to fully use all deceleration means, including speed brakes, wheel braking and reverse thrust irrespective of noise-related restrictions, until a safe stop is assured, unless this causes controllability issues.	Aircraft Operator	**End of 2021**
OPS24	Aircraft operators should publish SOPs and guidance and provide training highlighting the importance of active monitoring, including monitoring of the activation of the stopping devices on landing, and effective intervention during landing associated with pilot monitoring duties and performance. Appropriate training should be provided.	Aircraft Operator	**End of 2023**
OPS25	Aircraft operators should define policies and procedures to address bounced landings. Whenever available, aircraft operators should take into account and include manufacturers' guidance. Moreover, aircraft specific and appropriate training, including simulator training, should be provided for flight crews.	Aircraft Operator	**End of 2023**
OPS26	Aircraft operators should develop guidance on whether a change of control during landing roll out has to take place and require their flight crews to brief and agree on the planned runway exit, taking into account the friction status of both runway and runway exit, whenever available. When a change of control is necessary during roll-out, this should be performed below taxi speed and when the aircraft trajectory is stable.	Aircraft Operator	**End of 2023**

REF	Recommendation	Action by	Implementation Date
OPS27	Aircraft operators should implement policy, technical solutions or SOPs which confirm that the aircraft is lining up on the planned runway, its centreline and via the correct intersection.	Aircraft Operator	**End of 2023**
OPS28	Aircraft operators should publish SOPs and guidance for their flight crew not to accept line-up, backtrack or takeoff clearances until pre-takeoff preparation (including cabin secure), procedures and checklists are completed to the appropriate point which permits the accomplishment of the associated manoeuvre without delay and until they have reported "ready for departure" to ATC. Aircraft operators should publish an explicit SOP for "rolling takeoffs".	Aircraft Operator	**End of 2023**
OPS29	Aircraft operators should foster a culture that stimulates safe behaviour, which encourages risk-averse decision-making by flight crews.	Aircraft Operator	**Ongoing**
OPS30	Aircraft operators should, when determining their TEM strategies and SOPs, identify runways with a remaining safety margin of less than 400m/1200ft after application of all required safety factors as safety critical.	Aircraft Operator	**End of 2023**
OPS31	Aircraft operators should monitor go-around policy compliance through their FDM programmes and establish go-around safety performance indicators (SPIs) for monitoring through their SMS. In addition to monitoring go-arounds, aircraft operators should also monitor discontinued approaches.	Aircraft Operator	**End of 2023**
OPS32	Aircraft operators should: 1) Define an unstable approach followed by landing as a mandatory reporting event by the flight crew and; 2) Minimise the need to report a go-around due to an unstable approach unless there is another significant event in relation to the go-around, e.g. flap overspeed.	Aircraft Operator	**End of 2023**
OPS33	Aircraft operators, for aircraft equipped with EFBs and when technically feasible, should systematically compare the EFB takeoff performance loggings with the relative FDM data to identify the takeoff runway excursion risks.	Aircraft Operator	**End of 2023**
OPS34	Aircraft operators, for aircraft equipped with EFBs and when technically feasible, should visualise on the EFB the FULL RWY with its planned TO RWY holding position to increase the situational awareness of the crew for the intended T/O position.	Aircraft Operator	**End of 2023**
OPS35	Aircraft operators should consider observational procedures (e.g. Line Operations Safety Audits) to identify runway excursion safety risks precursors and best practices which cannot be captured by the traditional reporting or FDM.	Aircraft Operator	**End of 2023**

RECOMMENDATIONS TO AIRCRAFT MANUFACTURERS

REF	Recommendation	Action by	Implementation Date
MAN1	Aircraft manufacturers should present takeoff and landing performance information for dispatch and time-of-arrival for the full range of reportable runway conditions, using common and shared terminology and to agreed standards, set out in FAA ACs 25-31 and 25-32.	Aircraft Manufacturer	**End of 2025**
MAN2	Training material promulgated by aircraft manufacturers and aircraft training providers should emphasize the necessity of making best use of deceleration means, including speed brakes, wheel braking and reverse thrust in a timely manner, until a safe stop is assured, and in particular when conditions are uncertain or when runways are wet or contaminated by applying full braking devices, including reverse thrust, until a safe stop is assured.	Aircraft Manufacturer	**End of 2023**
MAN3	On-board real time performance monitoring and alerting systems that will assist the flight crew with the land/go-around decision and alert when more deceleration force is needed during the landing roll should be made widely available.	Aircraft Manufacturer	**End of 2027**
MAN4	The aviation industry should develop systems and flight crew manuals to help flight crews calculate landing distances easily and reliably in normal and non-normal conditions. Systems should have a method to apply recommended assumptions. All landing distance computing tools available for the aircraft (FMS, EFB) and on-board real time performance monitoring and alerting systems (e.g. ROAAS, etc.) should be consistent with the overall harmonized set of data used for landing performance assessment. Whenever consistency between on-board alert triggering thresholds and landing distance computation methods available to the crew cannot be entirely achieved, means to determine these thresholds for the planned conditions and guidance to the flight crew on a recommended course of action should be provided.	Aircraft Manufacturer	**End of 2025**
MAN5	Electronic Flight Bag manufacturers and providers should develop user interfaces for the calculation and data entry of the takeoff and landing performance data, designed to minimise the possibility of errors introduced by the pilot. EFB systems should enable the flight crew to perform independent determination of takeoff and landing data and to implement, where possible, an automatic cross-check of inputs and to ensure correct insertion of the data in the avionics. EFB systems should use terminology and presentation of data consistent with aircraft systems and aircraft documentation to the extent practical. Standard Operating procedures should be developed to support a cross-check of performance data by both pilots	Aircraft Manufacturer	**End of 2025**
MAN6	Manufacturers should monitor and analyse (worldwide) runway excursions involving the aeroplanes they support and share the lessons learned – where feasible.	Aircraft Manufacturer	**Ongoing**

REF	Recommendation	Action by	Implementation Date
MAN7	Manufacturers should provide information about effective crosswind landing and takeoff techniques including in low visibility when required.	Aircraft Manufacturer	**End of 2023**
MAN8	Manufacturers should consider a function able to: • Use aircraft data to compute braking action (i.e. maximum achievable tire-runway friction when braking is friction limited). • Display it to the crew to assist pilot's braking action report to air traffic control (PiRep). • Convey it, just after landing, to airport operators and to the aircraft operator(s).	Aircraft Manufacturer	**End of 2027**
MAN9	Manufacturers should consider to make available flight deck functionality enabling an accuracy of the 3D aircraft trajectory with regards to the runway (including the touch-down point), especially for degraded visibility landings. For example, in order to satisfy this recommendation manufacturers could consider to make available: • Expanded automatic landing. Or • Functions that provide additional information to the flight crew to improve positional awareness of the aircraft relative to the landing runway.	Aircraft Manufacturer	**End of 2027**
MAN10	Aircraft manufacturers and FDA service providers should provide adequate interfaces and consider developing additional services for Flight Data Analysis, to help operators identify precursors to runway excursions. For example, this could include services to identify: • Discrepancies on runway surface conditions (comparing experienced conditions with ATC reported ones) • Reduced aircraft performance margins at landing or takeoff, by comparing actual data (such as deceleration and distances) with the expected aircraft performance according to manufacturer models.	Aircraft Manufacturer	**End of 2027**
MAN11	Manufacturers should consider a real-time takeoff performance monitoring function in order to reduce the risk of runway excursion during takeoff, including aircraft performance related or wrong position scenarios.	Aircraft Manufacturer	**End of 2027**
MAN12	Manufacturers should consider to make available systems that provide flight path and energy state awareness in order to aid the flight crew to better anticipate and maintain stability throughout the entire approach.	Aircraft Manufacturer	**End of 2027**
MAN13	Manufacturers should provide recommendations in their operational documentation for the use of automatic braking when landing on wet or contaminated runways, when appropriate, to minimize delays in brake application.	Aircraft Manufacturer.	**End of 2021**

REF	Recommendation	Action by	Implementation Date
MAN14	Manufacturers should consider to make available on-board real time stabilized approach monitoring systems that provide alerts when there is a deviation from stable approach criteria. In those cases where other alerting systems are used in combination (e.g. ROAAS), the alerting systems must be consistent to avoid unnecessary go-arounds.	Aircraft Manufacturer	**End of 2027**
MAN15	Manufacturers should provide on-board real time means to enhance position awareness with respect to runways on final approach and ground operations to addresses risks of aircraft lining up on: • The incorrect runway for landing or departure. • A taxiway for landing or departure. • The incorrect intersection for departure.	Aircraft Manufacturer	**End of 2027**
MAN16	Whenever new functionality is created that is not supported by existing regulatory guidance, that functionality should be preferably supported by development of a MOPS by a standards organization.	Aircraft Manufacturer	**Ongoing**

RECOMMENDATIONS TO REGULATORS AND ICAO

REF	Recommendation	Action by	Implementation Date
REG1	Regulators should ensure that: • The national/regional regulations are in line with the relevant ICAO standards and recommended practices; and • All infrastructure, practices and procedures relating to runway operations are designed and remain in compliance with such national/regional regulations.	Regulators	**Ongoing**
REG2	Regulators should enhance the focus on the prevention of runway excursions in their oversight activities by taking into account best practices (e.g. GAPPRE), in addition to their national/regional regulatory requirements.	Regulators	**Ongoing**
REG3	Ensure that the risk of runway excursion is included as part of runway safety in the State Safety Plan and provide safety performance indicators to monitor/demonstrate the effectiveness of any State or industry initiatives.	Regulators	**Ongoing**
REG4	As part of their oversight activities, Regulators should ensure close cooperation between ground handling service providers, aircraft operators, aerodrome operators and air navigation service providers, with regard to the prevention of runway excursions. This cooperation will be a part of an effective implementation of SMS of the relevant organisations, verified by the respective regulator through regular assessments and safety performance indicator monitoring.	Regulators	**Ongoing**
REG5	Ensure that any noise mitigation rules required to be implemented by aerodromes should be subject to regular and co-ordinated hazard identification and risk assessment, to ensure they do not increase the likelihood of runway excursions, in particular in relation to operations on contaminated runways.	Regulators	**Ongoing**
REG6	Ensure a continued focus on training for pilots, air traffic controllers, AFISOs, and aerodrome personnel, which includes runway excursion prevention. Ensure the continuous review and improvement of the respective training programmes by the regulator and Training Organisations, through the use of performance indicators.	Regulators	**End of 2022**
REG7	Assess the performance of aircraft operators' processes for: • Safety data collection (e.g. flight data monitoring and reporting). • Identification and analysis of precursors and causal factors. Ensure that aircraft operators are participating in safety data sharing programs, e.g. Data4Safety.	Regulators	**End of 2022**
REG8	As part of safety promotion, ensure GAPPRE is shared with relevant stakeholders to ensure that the causal and contributory factors of runway excursion continue to be understood, enabling organisations to further enhance effective runway excursion prevention measures.	Regulators	**Ongoing**

REF	Recommendation	Action by	Implementation Date
REG9	States should assess the performance and success of safety information sharing networks among all users of the aviation system including the extent of free exchange of information on actual and potential safety deficiencies.	Regulators	**Ongoing**
REG10	States should establish a national runway safety forum/network which includes representatives from aircraft operators, ANSPs, aerodromes and regulators where best practices and learning can be shared. The National forum/network should include key representatives from Local Runway Safety Teams. National best practices should be shared regional/globally through regional/global knowledge platforms.	Regulators	**End of 2022**
REG11	States should measure the effectiveness of the GAPPRE recommendations, for example by collaboratively developing harmonised performance indicators or success factors.	Regulators	**End of 2022**
REG12	REG12 a. Regulators and ICAO should consider and adopt regulatory measures for preventing visual confusion during line-up between runway edge and centreline lights leading to misalignment with the runway centreline. This should also take into account the effects of low visibility and runway contamination and the effect of using various light colours and patterns to differentiate the runway centreline and edge lighting systems. REG12 b. Regulators and ICAO should consider the guidance needs of the individual aircraft, and adopt provisions that disassociate the installation of taxiway centreline lights from the aerodrome traffic density.	ICAO and Regulators	**End of 2025**
REG13	Except where runway TDZ lights are provided, regulators and ICAO should upgrade to a standard the use of simple TDZ lighting as an aid to enhance landing (touch down point) accuracy.	ICAO and Regulators	**End of 2025**
REG14	ICAO should investigate improvements in marking and lighting systems that may enhance the simple TDZ lighting system.	ICAO	**End of 2025**
REG15	ICAO should consider to upgrade to a standard the introduction of runway centreline lights for: • CAT I runways; • Runways used for takeoff with RVR of the order of 400m or higher when the runway is used by high-speed aircraft, particularly where the width between the runway lights is greater than 50 m.	ICAO	**End of 2025**
REG16	Support the development of approved signal in space SBAS models to allow certification of automatic landing on LPV 200 procedures as part of a broader initiative to promote and encourage the development of LPV 200 IFR procedures on a wider set of runways.	Regulators	

REF	Recommendation	Action by	Implementation Date
REG17	Regulators and ICAO should launch initiatives or working groups having the objective to define a rulemaking baseline for video based navigation to supplement (and/or replace) traditional navigation means in the visual segment. Such capacity would allow enhancing availability of advance functions such as automatic landing and veer-off prevention warnings.	ICAO and Regulators	**End of 2025**

RECOMMENDATIONS FOR R&D

REF	Recommendation	Action by	Implementation Date
R&D1	Investigate a awareness and alerting system when an aircraft experiences abnormal/significant lateral deviation during final stages of the landing.	States, international organisations and the Industry	**End of 2030**
R&D2	Conduct research on transport-category aircraft, to extend automatic landing capacity to any runway states.	States, international organisations and the Industry	**End of 2030**
R&D3	Improve methods for assessing runway micro texture. Make pilots and aerodrome operators aware of the impact of a poor micro texture and of the shortfalls of current industry practice.	States, international organisations and the Industry	**End of 2030**
R&D4	Develop models for assessing runway wetness, particularly the depth.	States, international organisations and the Industry	**End of 2030**
R&D5	Explore the accuracy of and develop new automatic runway condition monitoring systems.	States, international organisations and the Industry	**End of 2030**
R&D6	Research ways to improve graded area of wet runway strips to mitigate the damage to aircraft when veering off a runway.	States, international organisations and the Industry	**End of 2030**
R&D7	Research and develop functions that provide additional flight path and energy information (e.g. such as FPV symbology) in order to help the flight crew to better anticipate and maintain stability at the gate and below	States, international organisations and the Industry	**End of 2030**
R&D8	R&D efforts should be conducted to develop on-board real time stabilised approach monitoring (upstream of ROAAS function at higher altitudes eg FL 200). Such systems should ensure that they are harmonized with other systems such as ROAAS and Runway Awareness and Advisory System (RAAS).	States, international organisations and the Industry	**End of 2030**

LIST OF ABBREVIATIONS AND ACRONYMS

ACARS	Aircraft Communications Addressing and Reporting System
AFISO	Aerodrome Flight Information Service Officer
AGL	Aeronautical Ground Lighting
ANSP	Air Navigation Service Provider
APM	Approach Path Management
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATIS	Automatic Terminal Information System
ATS	Air Traffic Services
DA	Decision Altitude
EASA	European Union Aviation Safety Agency
EFB	Electronic Flight Bag
FAA	Federal Aviation Administration
FCOM	Flight Crew Operating Manual
FDA	Flight Data Analysis
FDM	Flight Data Monitoring
FL	Flight Level
FMS	Flight Management System
FPV	Flight Path Vector
GAPPRE	Global Action Plan for the Prevention of Runway Excursions
GNSS	Global Navigation Satellite System
GRF	ICAO Global Reporting Format
ICAO	International Civil Aviation Organisation
IFP	Instrument Flight Procedure
ILS	Instrument Landing System
LDA	Landing Distance Available
LPV	Localiser Performance with Vertical Guidance
LRST	Local Runway Safety Team
LVP	Low Visibility Procedures
MDA	Minimum Descent Height
METAR	Meteorological Terminal Air Report
MOPS	Minimum Operational Performance Standard
NOTAM	Notice to Airmen
PAPI	Precision Approach Path Indicator
PM	Pilot Monitoring
R&D	Research and Development
RAAS	Runway Awareness and Advisory System
RESA	Runway End Safety Area
ROASS	Runway Overrun Awareness and Alerting System
RWY	Runway
SBAS	Satellite-based Augmentation System
SMS	Safety Management System
SOPs	Standard Operating Procedures
SPI	Safety Performance Indicators
TDZ	Touchdown zone
TEM	Threat and Error Management
TODA	Takeoff distance available
TORA	Takeoff Run Available

GLOBAL ENHANCED ACTION PLAN FOR THE PREVENTION OF RUNWAY EXCURSIONS PART 2

GUIDANCE AND EXPLANATORY MATERIAL

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APPENDIX A
GUIDANCE AND EXPLANATORY MATERIAL FOR AERODROME OPERATORS

Recommendation ADR1: Ensure that runways are constructed, resurfaced and repaired in accordance with the national or regional (e.g., EASA) regulations, so that effective friction levels and drainage are achieved.

What

Regarding runway surface characteristics, design surface elements are included in regulations. Those design targets give specifications which ensure the runway surface is suitable for takeoffs and landings. Regulations usually include more stringent design targets as recommendations. These would usually ensure even safer conditions and therefore should be met as closely as possible. The basic surface elements consist of:

- The slopes;
- Grooves features; and,
- The texture of pavement.

Why

Regarding the slopes

Runways should meet the slope specifications in order to support aircraft manufacturer performance limitations and enable the safe movement of aircraft, in addition to facilitating water drainage. The latter acts towards the preservation of required adherence when braking/turning on the runway surface at the appropriate speed. In particular, the transverse slope enables the water to drain away from the runway centreline.

Regarding runway grooving

Grooved surfaces reduce both dynamic and viscous hydroplaning by further diminishing the watery surface area in contact with the tyre.

Regarding the texture of pavement

Adequate macro and micro texture ensure a minimum coefficient of friction and therefore enough adherence.

How

Recommendations concerning surface slopes and other physical features are provided in International Civil Aviation Organization (ICAO) Annex 14 and ICAO Aerodrome Design Manual, Doc 9157, Part 1.

Recommendation ADR2: An appropriate program should be effectively implemented to ensure the removal of contaminants from the runway surface as rapidly and completely as possible to minimise accumulation and preserve friction characteristics.

What

Removal of contaminants on the runway should be performed as soon as possible. Means of removal should be adapted to ensure efficiency, and the surface condition should then be checked against pre-determined minimum requirements. Three types of contamination are concerned: Temporary contamination that build up due to weather phenomenon (snow, ice, etc.), long term contamination such as rubber deposits with oily particles, and contamination that may or may not fade over time, depending on its nature and the environmental conditions (for example, sand).

Why

During periods of continuous contamination, it is essential to stay ahead of the curve so as not to get overwhelmed by accumulated contamination over time. Rapid removal should help in preserving the friction characteristics of the runway. If performed well, it will ensure that braking actions and steering capabilities of aircraft are not adversely affected when taking off or landing.

How

Each type of contamination should be considered separately if necessary (for water contamination, refer to *Recommendation ADR1*).

Winter contaminants

Ice, frost, snow and slush should be removed to enable safe operations. A combination of mechanical, chemical or other means can be used to ensure as much as possible is removed according to:

- The nature of the contamination (slush, ice, snow, frost);
- The depth of the contaminant;
- The solidity of the contaminant;
- The time of protection needed;
- The frequency and intensity of the contamination; and,
- Temperature and humidity evolution.

Rubber deposits

Among other parameters, rubber deposit accumulation depends on the traffic (number of landings), runway temperature and runway roughness. The severity of the phenomenon is also increased when dealing with heavy aircraft.

- Supposing no change in the traffic pattern, contaminant removal should be planned regularly at a given frequency.
- One should be careful regarding the means used to remove the rubber deposits: For example, very high pressurised water can accelerate the runway surface deterioration if the removal is performed too frequently. Less aggressive approaches exist to remove the rubber deposits:
  - Cryogenic removal, which is suitable for small surface accumulation as no "runway size" means are known today; and,
  - Chemical spreading (environmentally friendly).
- One way to define the most appropriate action could be by assessing the rubber deposit accumulation over time, matching the traffic (i.e., utilization of the runway) against friction characteristics. On a graph, a curve could be drawn where friction starts to deteriorate over time. This curve could be used to determine the best moment to start the removal. Over time, and when the traffic changes, the frequency of removal should be adapted.

Recommendation ADR3: If provided, ensure that approach radio navigation aids (e.g., ILS) and visual aids (e.g., AGL, PAPIs and surface markings) are maintained in accordance with ICAO Standards and Recommended Practices.

An appropriate method for the inspection and assessment of markings deterioration should be implemented.

What

The recommendation emphasizes the necessity to follow ICAO standards and recommendations for visual and radio navigation aids maintenance and consolidate best practices for the inspection of markings.

Why

The availability of location information supported by signs, lights and markings, both along the runway and at the holding points, provides the flight crew with enhanced situational awareness as they indicate where the aircraft is relative to the airport layout. This information is beneficial in reducing the likelihood of runway excursions, particularly as the presence of the aids will assist flight crew in ensuring the takeoff roll commences at the correct location. Also, lighting, radio navigation aids (e.g., instrument landing system (ILS), aeronautical ground lighting (AGL), precision approach path indicator (PAPI)) and runway markings all help flight crews to fly an adequate flight path to the expected touchdown point on the runway, thus avoiding long and short landings.

How

Lightings and signs are already thoroughly covered through the current regional regulations. Markings should also be inspected for any sign of changes:

Rubber deposits

- Markings should be inspected visually to ensure they are not becoming obscured by rubber deposits, specifically in the touchdown zone, with a frequency that must be related to the traffic density, the use of the runway and the meteorological conditions at the airport.

Degradation of markings

Not all markings shall be assessed equally during inspection: The emphasis should be on critical areas where marking is known to deteriorate quickly. Again, touchdown zone (TDZ) markings and the runway centreline should be inspected at a higher frequency; runway centerline markings help in reducing the risk of veer-offs, and TDZ markings can reduce the risk of overruns. In any case, the frequency should be adequate to ensure visual identification is maintained. The rest of the markings not subject to an accelerated deterioration, or critical in regard to veer-offs and overruns risks, can follow a program of planned maintenance based on the age of the marking, the weather conditions and the volume of traffic.

Here is some guidance that can help in performing effective inspection of markings:

- Inspections are realised by individuals familiar with characteristic deteriorations of markings (training);
- Sufficient light is present for adequate visual assessment; and,
- For aerodromes where markings are deteriorating abnormally fast (aggressive environmental conditions or excessive run-over), further advanced methods based on chromaticity and retro-reflectivity can be developed.

The inspection of markings can take into account the following references:

- "Development of Methods for Determining Airport Pavement Marking Effectiveness", DOT/FAA/AR-TN03/22.
- Airfield Marking Handbook, in APPENDIX D: Criteria for Maintenance, in defined a threshold pass/fail limit for white and yellow paint.

Radio-navigation and lighting

Radio-navigation aids and lighted visual aids should be checked periodically for alignment and synchronicity in order to ensure there are no conflicts in the information provided to the flight crew.

Recommendation ADR4: Ensure that the runway holding positions are clearly marked, signed and if required, lighted. If intersection takeoffs are conducted, install at the relevant runway holding positions signs to indicate the Takeoff Run Available (TORA).

What

All intersecting taxiways intended to be used for departure should be equipped with signs properly illuminated and visible, indicating the takeoff run available (TORA).

Why

The updated TORA from the entrance taxiway should be indicated as a last resort prior to takeoff. As such, any inadequacy with the required distances calculated for performance can be addressed during the takeoff briefing.

How

Implementation of TORA information signs in conformity with the applicable regulation (Figure 1).

Refer to ICAO Annex 14 for signage implementation and design standards.

Figure 1. **The design specifications are in line with the corresponding ones of ICAO Annex 14, Volume I**

Extracted from EASA CS-ADR-DSN

Recommendation ADR5: Ensure robust procedures are in place for calculating temporary reduced declared distances (e.g., due to work in progress on the runway). When reduced declared distances are in operation, ensure that the temporary markings, lighting and signs accurately portray the reduced distances and that they are well communicated in a timely manner to the state's aeronautical information services for publication and the relevant ATS units.

What

Should the runway declared distances be temporarily reduced for any reason, for example during maintenance or construction work, signs, markings and lighting should be carefully planned to ensure the correct temporary information is displayed. These reduced distances need to be carefully determined as they are used in aircraft performance calculations by the aircraft operators. Temporarily reduced runway distances must also be carefully communicated to flight crew by Notices to Airmen (NOTAMs) and/or Aeronautical Information Publication Supplements (AIP SUP), to air traffic services (ATS) for inclusion in automatic terminal information service (ATIS) broadcasts, flight briefing material or live radio communication.

Why

Temporarily reduced declared distances require extra attention. A number of occurrences have taken place in which flight crews had not detected a change and planned a takeoff or landing based on the normal declared distances.

How

Signage

Variable message signs displaying text specific to temporary changes may be useful in certain circumstances. It is also good practice to cover any previous and permanent signs that present conflicting information, so there is only one sign present.

Recommendation ADR6: Ensure that the procedures to assess runway surface conditions according to the Global Reporting Format (GRF) include reactive as well as proactive surface assessment to make sure hazardous changes are all identified and communicated in a timely manner.

What

When a meteorological degradation is expected, the aerodrome operator will ensure that it is prepared to evaluate the surface conditions promptly to transmit relevant data to the air navigation services provider (ANSP) and through the appropriate aeronautical information channels.

Why

Pilots aware of the latest runway surface conditions perform more relevant preparations for takeoff and landing.

How

Proactive aspects of assessment should include:

- A regular and formalized monitoring of the weather to ensure prompt reactivity; and,
- Assessments should be performed at least when there is a change according to the significant change criteria stated in ICAO Doc 9981. Additional occasions, when the assessment should be performed in the aftermath of any removal of the contaminant, should be identified and formalized in clear procedures.

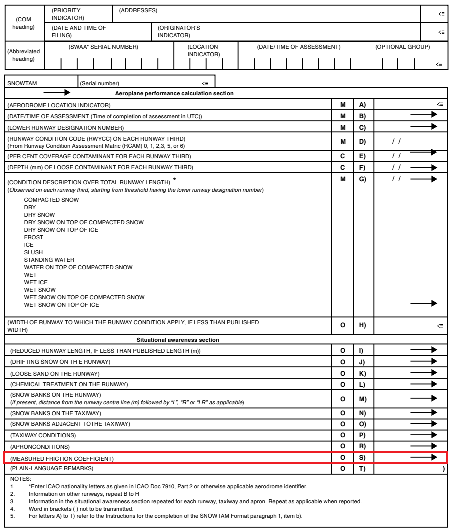
Assessments

A combination of additional means of assessments can be used to support visual observations by trained personnel:

- Friction measurements along the runway with adapted mobile equipment;
- Probe alerts (directly implemented on the runway) measuring humidity/temperature and depth of the contaminants; and,
- Pilot reports.

Data transmission

Friction measurements are not used by flight crews to calculate landing performance requirements. Therefore, the airport operator and the ANSP should not provide them with this information for states following EASA regulations: Only GRF shall be used. Item "S" of a SNOWTAM shall be filled with "NR" in this case (see below).



(COM heading) (PRIORITY INDICATOR) (ADDRESSES) <≡
(DATE AND TIME OF FILING) (ORIGINATOR'S INDICATOR) <≡
(Abbreviated heading) (SWAA* SERIAL NUMBER) (LOCATION INDICATOR) (DATE/TIME OF ASSESSMENT) (OPTIONAL GROUP) <≡

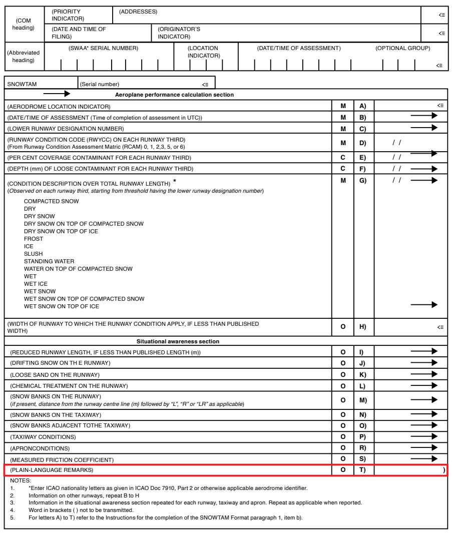
SNOWTAM (Serial number) <≡

Aeroplane performance calculation section			
(AERODROME LOCATION INDICATOR)	M	A)	<≡
(DATE/TIME OF ASSESSMENT (Time of completion of assessment in UTC))	M	B)	→
(LOWER RUNWAY DESIGNATION NUMBER)	M	C)	→
(RUNWAY CONDITION CODE (RWYCC) ON EACH RUNWAY THIRD) (From Runway Condition Assessment Matric (RCAM) 0, 1, 2,3, 5, or 6)	M	D)	/ /
(PER CENT COVERAGE CONTAMINANT FOR EACH RUNWAY THIRD)	C	E)	/ / →
(DEPTH (mm) OF LOOSE CONTAMINANT FOR EACH RUNWAY THIRD)	C	F)	/ / →
(CONDITION DESCRIPTION OVER TOTAL RUNWAY LENGTH) * (*Observed on each runway third, starting from threshold having the lower runway designation number*) COMPACTED SNOW DRY DRY SNOW DRY SNOW ON TOP OF COMPACTED SNOW DRY SNOW ON TOP OF ICE FROST ICE SLUSH STANDING WATER WATER ON TOP OF COMPACTED SNOW WET WET ICE WET SNOW WET SNOW ON TOP OF COMPACTED SNOW WET SNOW ON TOP OF ICE	M	G)	/ / →
(WIDTH OF RUNWAY TO WHICH THE RUNWAY CONDITION APPLY, IF LESS THAN PUBLISHED WIDTH)	O	H)	<≡
Situational awareness section			
(REDUCED RUNWAY LENGTH, IF LESS THAN PUBLISHED LENGTH (m))	O	I)	→
(DRIFTING SNOW ON TH E RUNWAY)	O	J)	→
(LOOSE SAND ON THE RUNWAY)	O	K)	→
(CHEMICAL TREATMENT ON THE RUNWAY)	O	L)	→
(SNOW BANKS ON THE RUNWAY) (*if present, distance from the runway centre line (m) followed by "L", "R" or "LR" as applicable*)	O	M)	→
(SNOW BANKS ON THE TAXIWAY)	O	N)	→
(SNOW BANKS ADJACENT TOTHE TAXIWAY)	O	O)	→
(TAXIWAY CONDITIONS)	O	P)	→
(APRONCONDITIONS)	O	R)	→
(MEASURED FRICTION COEFFICIENT)	O	S)	→
(PLAIN-LANGUAGE REMARKS)	O	T)	)

NOTES:
1. *Enter ICAO nationality letters as given in ICAO Doc 7910, Part 2 or otherwise applicable aerodrome identifier.
2. Information on other runways, repeat B to H
3. Information in the situational awareness section repeated for each runway, taxiway and apron. Repeat as applicable when reported.
4. Word in brackets ( ) not to be transmitted.
5. For letters A) to T) refer to the Instructions for the completion of the SNOWTAM Format paragraph 1, item b).

Item "S" Highlighted

If the contamination is asymmetrical on the runway (with the left side or right side of the runway more prominent), it could be specified as additional information in item "T" of a SNOWTAM (see below).



(COM heading) (PRIORITY INDICATOR) (ADDRESSES) <≡
(DATE AND TIME OF FILING) (ORIGINATOR'S INDICATOR) <≡
(Abbreviated heading) (SWAA* SERIAL NUMBER) (LOCATION INDICATOR) (DATE/TIME OF ASSESSMENT) (OPTIONAL GROUP) <≡

SNOWTAM (Serial number) <≡

Aeroplane performance calculation section			
(AERODROME LOCATION INDICATOR)	M	A)	<≡
(DATE/TIME OF ASSESSMENT (Time of completion of assessment in UTC))	M	B)	→
(LOWER RUNWAY DESIGNATION NUMBER)	M	C)	→
(RUNWAY CONDITION CODE (RWYCC) ON EACH RUNWAY THIRD) (From Runway Condition Assessment Matric (RCAM) 0, 1, 2,3, 5, or 6)	M	D)	/ /
(PER CENT COVERAGE CONTAMINANT FOR EACH RUNWAY THIRD)	C	E)	/ / →
(DEPTH (mm) OF LOOSE CONTAMINANT FOR EACH RUNWAY THIRD)	C	F)	/ / →
(CONDITION DESCRIPTION OVER TOTAL RUNWAY LENGTH) * (*Observed on each runway third, starting from threshold having the lower runway designation number*) COMPACTED SNOW DRY DRY SNOW DRY SNOW ON TOP OF COMPACTED SNOW DRY SNOW ON TOP OF ICE FROST ICE SLUSH STANDING WATER WATER ON TOP OF COMPACTED SNOW WET WET ICE WET SNOW WET SNOW ON TOP OF COMPACTED SNOW WET SNOW ON TOP OF ICE	M	G)	/ / →
(WIDTH OF RUNWAY TO WHICH THE RUNWAY CONDITION APPLY, IF LESS THAN PUBLISHED WIDTH)	O	H)	<≡
Situational awareness section			
(REDUCED RUNWAY LENGTH, IF LESS THAN PUBLISHED LENGTH (m))	O	I)	→
(DRIFTING SNOW ON TH E RUNWAY)	O	J)	→
(LOOSE SAND ON THE RUNWAY)	O	K)	→
(CHEMICAL TREATMENT ON THE RUNWAY)	O	L)	→
(SNOW BANKS ON THE RUNWAY) (*if present, distance from the runway centre line (m) followed by "L", "R" or "LR" as applicable*)	O	M)	→
(SNOW BANKS ON THE TAXIWAY)	O	N)	→
(SNOW BANKS ADJACENT TOTHE TAXIWAY)	O	O)	→
(TAXIWAY CONDITIONS)	O	P)	→
(APRONCONDITIONS)	O	R)	→
(MEASURED FRICTION COEFFICIENT)	O	S)	→
(PLAIN-LANGUAGE REMARKS)	O	T)	)

NOTES:
1. *Enter ICAO nationality letters as given in ICAO Doc 7910, Part 2 or otherwise applicable aerodrome identifier.
2. Information on other runways, repeat B to H
3. Information in the situational awareness section repeated for each runway, taxiway and apron. Repeat as applicable when reported.
4. Word in brackets ( ) not to be transmitted.
5. For letters A) to T) refer to the Instructions for the completion of the SNOWTAM Format paragraph 1, item b).

Item "T" Highlighted

Training

When a equipment or a procedure are required to be used only during a part of the year, ensure that personnel are trained outside of that season for that equipment/procedure so that skills can be maintained. This should be emphasised right before that season, especially when new approaches are introduced for the first time. Seasonal training is necessary to:

- Identify all personnel involved in the process of assessment and transmission;
- Identify the role of all personnel; and,
- Plan for multiple training sessions if necessary, in advance and with practical tests until the entire process demonstrates error-proof transmission.

Feedback

Runway condition codes (RCCs) should be compared against braking action reported by the pilots to ensure improvement of the involved processes. This is especially important when reports are converging and do not match RCC.

> **Recommendation ADR7:** Ensure robust procedures are in place for communicating information regarding changing surface conditions as frequently as practicable to the appropriate services, according to the GRF. Roles, responsibilities of stakeholders and coordination procedures should be formalised.

What

Enhance the assessment and transmission cycles of runway surface conditions.

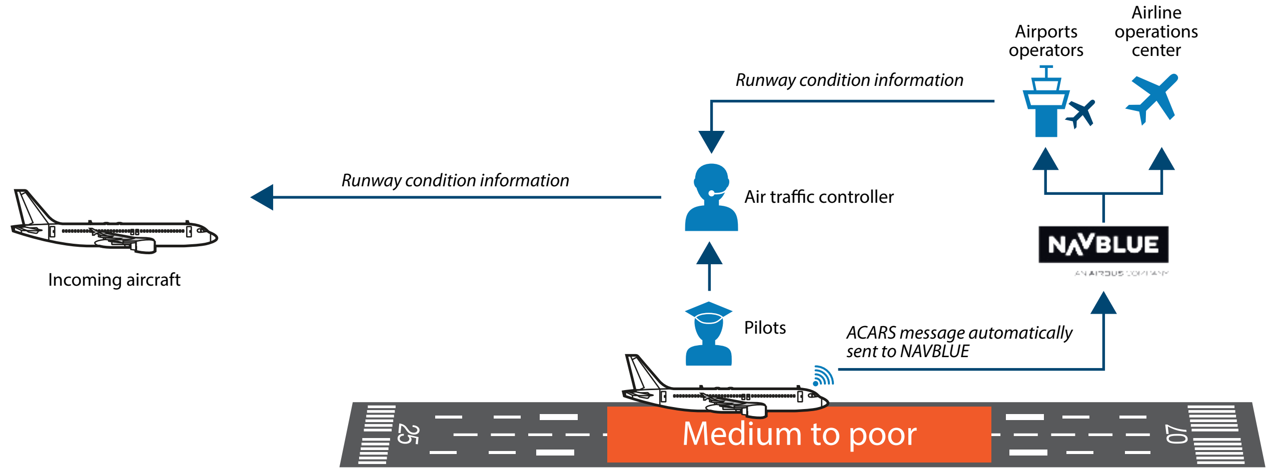
Why

It is necessary to ensure efficient cycles of transmission. Therefore, roles of all stakeholders must be defined and agreed upon to avoid possible missing steps contributing to increased delay. Delays generate hazardous situations when operational readiness is regularly impacted. Transmission of data during changing conditions may benefit from more frequent cycles of measurement. However, it should be carefully balanced with higher risks generated by the frequent interruptions of movements as a consequence of the unavailability of the runway during measurement.

How

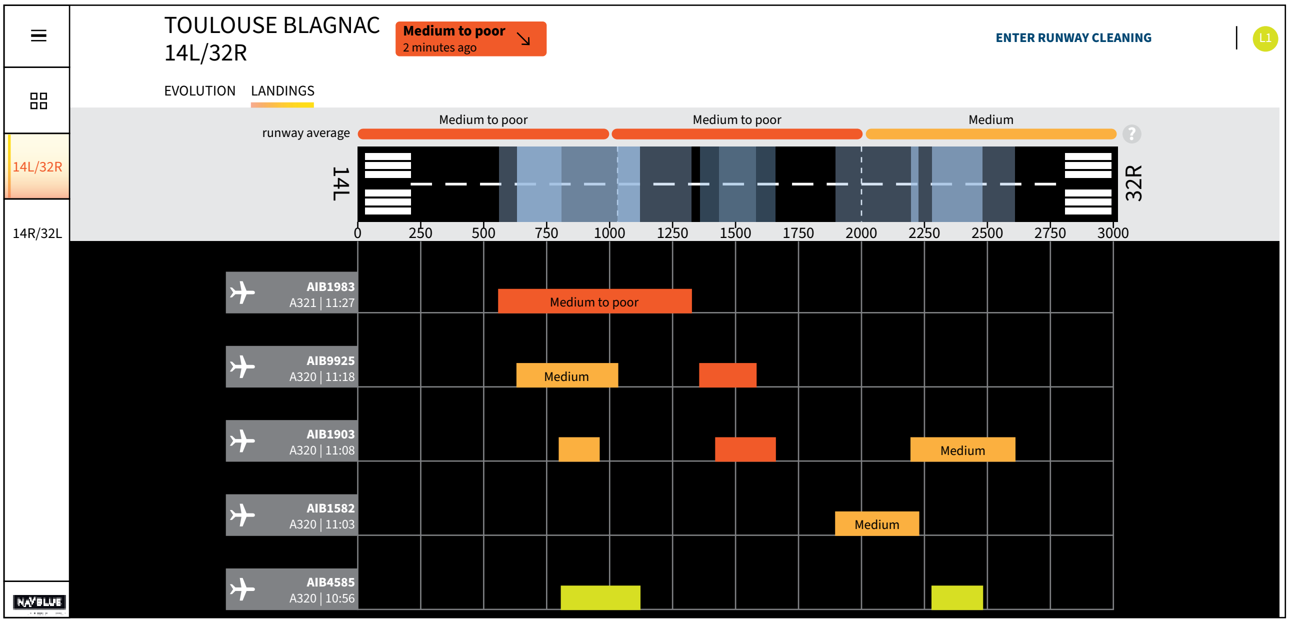
Methods are being developed that cannot supplant "usual" assessment but can give additional information on runway conditions without impacting the arrival or the departing sequence. They rely on the use of aircraft braking action data collected from actual landings. The data are automatically updated and made available to airports and/or air traffic

Figure 2. **Example automatic braking action data collection and transmission process**



Courtesy of NAVBLUE – RunwaySense/

Figure 3. **Example of braking action data monitoring**



Courtesy of NAVBLUE – RunwaySense

control (ATC). The data can be considered provided there is appropriate access to the information in a timely manner and that the information is accurate enough. Communication between actors should be clearly defined to ensure the role of each stakeholder in the process is clearly understood.

Recommendation ADR8: In accordance with ICAO standards (and regional, e.g. EASA regulations), wind sensors and wind direction indicators (wind socks) should be sited to give the best practical indication of conditions along the runway and touchdown zones.

What

Wind sensors consist of multi-directional anemometers measuring the direction of the wind and its speed. Their location may influence their measurements, and that should be taken into consideration when they are positioned. Windsocks should follow equivalent requirements with the objective to give information directly to pilots.

Why

Provision of accurate wind data is important for both landings and takeoffs. Tail winds and crosswinds have contributed to numerous runway excursions and accidents.

How

In order to ensure appropriate indication of winds, implementation of the equipment should take into consideration the following ICAO references:

- ICAO Manual 8896: Manual of Aeronautical Meteorological Practice; and,
- ICAO Annex 3: Meteorological Service for International Air Navigation.

An aeronautical meteorologist should lead related implementations in coordination with the aerodrome operator and the ANSP.

> **Recommendation ADR9:** Consider equipping for digital transmission of ATIS as appropriate to ensure that ATIS information is updated in a timely manner.

What

ATIS may still be prepared manually in some large aerodromes. ATIS should be prepared and published automatically on the basis of a computerized program scheduled at a known frequency rate.

Why

Having automatic D-ATIS (digital ATIS) ensures that:

- Pilots will receive the information in the same format every time, as digital ATIS reports are standardized;
- There will be a greater frequency of publication to ensure up-to-date information to pilots;
- The ATC workload will be reduced; and,
- The report has an increased range and can be consulted long before getting close to the airport.

How

The aerodrome operator or ANSP (whoever is in charge of this type of equipment) should consider equipping the aerodrome with data link systems that allow flight crews to obtain the latest weather without one pilot leaving the active frequency (e.g., D-ATIS using an Aircraft Communications, Addressing and Reporting System (ACARS)). ATIS shall be issued at least every 30 minutes.

> **Recommendation ADR10:** If installed, runway centreline lights should also be used together with the runway edge lights whenever runway edge lights are switched on and when the runway is in use.

What

When it is required to switch on the runway edge lights, during the night or in reduced visibility conditions, runway centreline lights should also be switched on, even though the visibility conditions do not necessarily call for the centreline lights to be on. Of course, this applies to aerodromes already equipped with centreline lights.

Why

It improves the awareness of the pilot as to where he/she is positioned relative to the centreline of the runway when visibility is reduced but still above CAT II minima or at night. It gives additional information about aircraft not lined up with the runway and hence reduces the risk of lateral excursion.

How

Two approaches can be followed:

- When the aerodrome lighting system is being designed, updated or reconfigured, it is possible to couple the centreline lights with the edge lights to make sure they can only be switched together.
- For airports not equipped with a coupled system, where groups of lights can only be switched separately, operational procedures should be in place for ATC so that edge lights are not illuminated without the centreline lights.

Note: *Whatever the approach used, associated technical requirements such as the switch-over times must be according to the more restrictive centreline lights.*

> **Recommendation ADR11:** Ensure appropriate coordination with the meteorological service provider, the ANSP and the aircraft operators to regularly assess the relevancy of weather data, in particular at large aerodromes where there could be spatial differences in weather data.

What

Meteorological data such as wind or visibility data may sometimes differ from what the pilots observe. When such differences are abnormally frequent, appropriate coordination involving the meteorological services office, the ANSP and the aerodrome operator should be in place to ensure discrepancies are analysed for possible recommendations to be established.

Why

The objective is to ensure that the data transmitted to the pilots describe appropriately the conditions they will encounter when taking off or landing. As such, takeoffs and landings do not present hazards generated by the possible diverging information.

How

It is essential to encourage pilots and ANSPs to report any gap observed by pilots between actual conditions and transmitted conditions.

The transmission of these operational feedbacks to the meteorological office can be formalized in an appropriate protocol in coordination with the ANSP.

Recommendations could include actions such as the redeployment of a directional anemometer.

Recommendation ADR12: Ensure runway exits are appropriately named according to a logic of succession of numbers and letters avoiding possible ambiguity.

What

Taxiways connected to the runway should be named in a logical order represented by successive letters or successive numbers (associated with the same letter) so that the latest number or letter matches the end of the runway.

Why

Providing a logical sequence of taxiway intersections assists pilots in determining their position on the runway and identifying the correct entry/exit point. This may support both the correct identification of the start of roll and the approximate estimation of the runway length left.

How

The sequencing of the taxiways should appear in the name of these taxiways along the runway in a clear and unambiguous logical order of succession.

Example: Z5-Z6-Z7-Z8 representing the four exits of the runway from the first to the last, Z8 is at the runway end. Z1 to Z3 are only used for line-ups (Figure 4).

Refer to "from the briefing room" document: A case study established for Paris-CDG airport:

https://www.skybrary.aero/bookshelf/books/3088.pdf

Recommendation ADR13: Runway surroundings should be considered when designing or modifying strips or runway end safety areas (RESAs). It is necessary to consider the local constraints against ICAO provisions and regional (e.g., EASA) regulations so as to ensure relevant mitigation.

What

When designing or modifying RESA and/or strips at an airport, it is important to take into consideration runway surroundings, including the area beyond graded strips.

Why

Runway surroundings can mitigate the consequences of an excursion if they are properly taken into consideration in the design process.

How

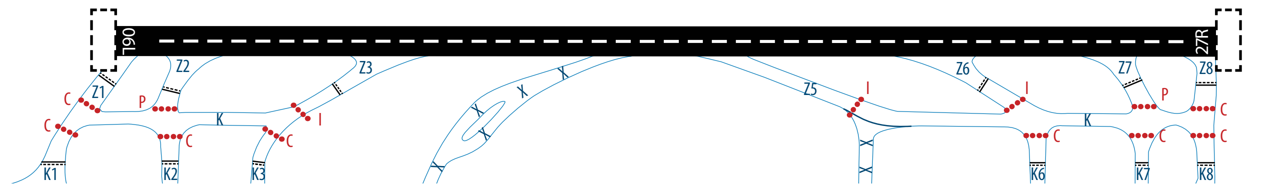
Local ground consideration

Unmodified grounds should be taken into consideration when designing runway surroundings beyond the graded runway strip so as to mitigate the effects of a runway excursion. A safety assessment should be done to reach the best scenario development for the strips and RESAs as regard safety objectives.

Aircraft arresting system

The assessment of the implementation of an aircraft arresting system (AAS), in accordance with the most recent ICAO determinations on AAS implementation, can be initiated as it could prove to be an appropriate solution where RESA distances are not enough to reach safety objectives. A detailed set of mitigation measures to runway excursion risks (operational, physicals) can be found in the ICAO PANS-ADR Appendix to Chapter 4: Physical characteristics of aerodromes.

Figure 4. **Extract of Paris-CDG AD 2 LFPG ADC 02 (aeronautical information)**



Recommendation ADR14: Information related to air operations hazards or specificities in the airport vicinity should be identified and addressed to pilots in the local runway safety team (LRST) and published through an appropriate means.

Communication and publications

Auxiliary sources of aeronautical information available to pilots highlighting specific hazards not necessarily mentioned in the AIP can be developed locally by an aerodrome in coordination with ANSPs, and local operators. They cannot and should not replace the regulated reference aeronautical information (AIP, AIC, NOTAMS, etc.).

The "CASH" solution in France is an example. Developed by the French civil aviation authority, CASH (Collaborative Aerodrome Safety Highlights) is a collective safety initiative, which aims to draw the attention of commercial and general aviation pilots to the aeronautical context and the main threats associated with an aerodrome. The identification of these threats is the result of collaborative work between platform operators (air operators, aerodrome operator, ANSP, flying clubs, meteorological services, etc.) obtained by comparing the elements of their safety management systems (SMS). The members of the local safety team of each platform validate this information and it is published on Internet, accessible to all users of the platform.

More information can be found at:

https://www.ecologie.gouv.fr/en/collaborative-aerodrome-safety-highlights-eng

Other examples of this kind of initiative in Europe include:

- The familiarization manual for air operators at the Andorra-La Seu d'Urgell Airport. It includes relevant and detailed information about airport procedures, aerodrome flight information service, special orography and disturbances in the vicinity. It involves a detailed study of particular factors that may affect the operation.
- At Gstaad Airport (LSGK), pilots wishing to fly in must be familiar with the various peculiarities associated with air traffic operations into and out of LSGK, including the relatively short landing runway with nearby obstacles around and along its axes and the non-standard traffic pattern with regular glider activity.

More information can be found at:

https://www.gstaad-airport.ch/wpcontent/uploads/2020/07/200101_pilots_briefing_v10.pdf

Recommendation ADR16: Consider using approach path management in coordination with local ATC and aircraft operators. Associated issues should be addressed by the LRST.

What

The decision-making processes involving the aerodrome operator and the ANSPs regarding the occupancy of the runways and any other factors possibly affecting the arrival sequence, should be assessed and optimized to reduce the impact of such decisions on approach path management and any last-minute alterations of the approach path.

Why

Aircraft energy management during the approach in reaction to last-minute changes, short windows, etc. can drastically affect the speed, braking and control of the aircraft during landings.

How

Runway interventions such as runway inspection, snow removal, intertwined departures and arrivals on the same runway or interdependent runways should be addressed, and their impact assessed, in coordination with ANSPs and the major based airlines.

A dedicated collaborative decision-making cell (CDM) can be developed; it would include the major stakeholders stated above. When degrading conditions are expected (weather, abnormal traffic, etc.), the CDM could be summoned. The stakeholders would then assess data and implement in real time the appropriate course of action collaboratively to ensure the impact on the arrival sequence is kept to a minimum.

More information regarding the establishment of a CDM can be found in the following:

https://www.eurocontrol.int/concept/airport-collaborative-decision-making

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APPENDIX B
GUIDANCE AND EXPLANATORY MATERIAL FOR AIR NAVIGATION SERVICE PROVIDERS

Preface

Recognising that aircraft operators are the subject of most of the safety recommendations included in the current edition of the Action Plan, it is also important to realise that air navigation service providers (ANSPs) have a role to play and should contribute to runway excursion risk reduction.

Air traffic controllers (ATCOs) routinely contribute to the prevention of runway excursions by helping flight crews fly stabilised approaches by adhering to procedures and, for instance, avoiding short-cuts that prevent flight crews from losing necessary altitude and speed during the approach. Moreover, through the provision of safety-significant, essential information about changes to surface wind, reduced runway lengths and runway surface conditions, ATCOs and aerodrome flight information service officers (AFISOs) ensure that flight crews have the latest aerodrome information available to enable safe takeoffs and landings.

However, breakdowns in these ATC/FIS functions can have undesired outcomes. For instance, sub-optimal control techniques, such as late descent and inappropriate speed control, can contribute to aircraft flying unstabilised approaches with an increased risk of runway excursion. In addition, interruptions, omissions or errors in the flow of essential information may deprive flight crews of operational safety decision-making information at critical stages of flight.

The following guidance material is intended to explain the rationale behind the relevant recommendations of the GAPPRE and to provide guidance on their practical implementation. The guidance material refers to relevant International Civil Aviation Organization (ICAO) standards and recommended practices (SARPs), meant to be transposed in national/regional regulations. In some instances, 'case study examples' are provided to amplify and provide additional reference to the issue being considered.

ANSPs, AFIS providers and ATCO/AFISO training organisations are invited to review the guidance material and, where appropriate, amend their training programmes and operating procedures and/or practices, as well as related information processing and dissemination tools.

Stabilised approach and correct departure performance calculation and aircraft set up

Recommendation ANSP1: Ensure the importance of a stabilised approach, its elements, compliance with final approach procedures and aircraft energy management are included in initial and refresher training of ATCOs conducted by ANSPs and ATCO training organisations, as well as in AFISOs training, as applicable.

Recommendation ANSP2: With regard to assignment of or change to runway assignment for arriving or departing aircraft:

ANSP2 a: Whenever the runway change is pre-planned, notify it to the flight crews as early as practicable, together with the expected time of the change, including by adding relevant information in automatic terminal information service (ATIS) broadcasts, where available.

ANSP2 b: As far as practicable, avoid changing the assigned runway to aircraft on approach or taxiing for departure.

ANSP2 c: Ensure ATCOs are aware that runway changes create additional workload, increase vulnerability to error, and that flight crews need time to re-brief and prepare for them.

ANSP2 d: Ensure that the runway configuration change procedure/process takes account of the above points and of the tailwind information, as appropriate.

ANSP2 e: When operationally possible, accept the flight crew's preference for a runway when requested due to performance limitations.

Why should ANSPs follow the recommendations?

It's well accepted throughout the aviation industry that a prerequisite for a safe landing is a stabilised approach. Regional and national regulations, as well as ICAO Procedures for Air Navigation Services – Aircraft Operations (PANS OPS, Doc 8168) or International Air Transport Association (IATA) Operational Safety Audit (IOSA) standards clearly demand stable approach policies and reflect the criteria for a stable approach concept as sparked by the Flight Safety Foundation Approach and Landing Accident–Reduction (ALAR) Tool Kit more than 20 years ago.

Approach path management is a collaborative task shared by flight crews and ATCOs/AFISOs. It includes aircraft trajectory and energy management. Although pilots play the major role and have the overall responsibility for it, air traffic services (ATS) can affect both elements by timely provision of information to flight crews that will help them anticipate the approach path to be flown, speed restriction, vectoring (including short cuts) and altitude clearances. Thus, ATCO/AFISO can contribute in a positive (uneventful approach and landing) or negative way (unstabilised approach that may be followed by a go-around or, in the worst case, a runway excursion) to the execution of this critical phase of flight.

Investigations of numerous incidents and accidents have led to the conclusion that mismatch of actual runway conditions and pilots' aircraft performance calculations and aircraft set-up for departure could influence the risk of runway excursions. ATS pressure on flight crew and late runway changes can be a contributing factor.

What can ANSPs do to implement the recommendations?

ATCO/AFISO should be aware of the following elements of a stabilised approach indicating an aircraft is on the correct flight path:

- Instrument landing system (ILS) approach — ILS within 1 dot of the localiser and glide slope on primary flight display/navigation display;
- Visual approach — wings level at 500 feet above ground level (AGL);
- Circling approach — wings level at 300 feet AGL;
- Only small heading and pitch changes required;
- Speed within +20/-0 knots of reference speed;
- Aircraft must be in proper landing configuration;
- Maximum sink rate of 1,000 feet per minute; and,
- In instrument meteorological conditions — stable by 1,000 feet AGL; in visual meteorological conditions — stable by 500 feet AGL.

ATC procedures and techniques should take into account the following:

Vectoring versus published arrival procedures. Routine vectoring of aircraft off a published arrival procedure to shorten the flight path should be avoided. Unexpected shortcuts may lead to insufficient time and distance remaining to maintain the desired descent profile and may result in the aircraft being high on the approach. Close-in turns to final, including visual approach positioning, which does not permit the flight crew to execute a stabilised approach, should be avoided.

Speed control instruction. Inappropriate speed control instructions that are incompatible with aircraft performance should be avoided. When assigning a speed restriction, the ATCO should take into account the distance to go, the required vertical profile below Flight Level (FL) 100 and any significant head wind or tail wind components at altitude. The objective is to allow the pilot to manage the energy state of their aircraft in a way that will ensure a stabilised approach. Assigning speed control close-in to the runway may lead to unstable approaches. ANSPs, when developing stabilised approach training, should consider the need to include specific training on aircraft energy management and its limits. Involvement of aircraft operators in the design and delivery of the training will enhance ATCO knowledge of the impact of speed restrictions and energy management on the overall approach path management by flight crew and ATC.

Distance to go information. When providing vectors, it is necessary to initially advise (and where appropriate, periodically provide) flight crews with estimated track miles to go. In terminal manoeuvring areas/control zones (TMAs/CTRs) where a 'standard' vectoring pattern for final approach is used and this is well known to flight crews, provision of estimated track miles to go may be limited to non-standard situations, short cuts and flights by aircraft operators that do not operate regularly to that aerodrome. Misinformation on track miles prevents crews from managing their descent effectively, and where the actual track miles are less than advised, this can lead eventually to circumstances conducive to an unstabilised approach.

Descent instructions. Delaying descent and keeping aircraft unduly high may result in flight crews requesting additional track miles, which may interfere with the planned sequence of landing and departing aircraft and/or contribute to high-energy unstabilised approaches.

Flight crew briefing. ATCOs and AFISOs should understand the importance of the flight crew approach brief. This has a single common objective — to preview what will or might happen during an imminent approach and landing. There is no such thing as a typical briefing, but the time to complete the majority of them might be within the range of two to six minutes, and it can be expected to be conducted 10 minutes before reaching the top-of descent point. Any approach re-briefing that might have to be conducted later would be at risk of being interrupted by either ATC communications and/or aircraft management priorities.

Approach type change. A change of instrument approach without adequate prior notification is undesirable at any time after an aircraft has left the higher of cruise altitude or (typically) FL100 in descent to destination. A 'late' change from a precision to a non-precision approach can be significant and may not always be feasible unless additional track miles are provided.

Runway change. Last minute runway changes, even to a parallel runway, should be avoided. To comply with the company's operating procedures and requirements, the flight crew must have time to properly brief the approach and missed approach procedure to the runway to be used. Even though a pilot may accept a runway change, the result may be an unstable approach.

Runway selection. Runway selection for operations should be based on safety considerations (e.g., best length and/or wind conditions) and not primarily on capacity, ATC convenience or environmental/noise abatement reasons. However, it is recognised that at some locations for a variety of reasons, the latter factors do influence the selection of the runway in use. In these circumstances, it is incumbent on ATC to monitor the situation carefully and advise flight crews, for instance, about tail winds. There is a balance to be struck, but when in doubt, safety considerations must assume primacy.

Controllers should accommodate crew requests for runways most aligned with the wind. When changing the runway configuration due to wind, ATCO should follow a defined procedure, articulate the last aircraft to land on the current runway and first aircraft to land on the 'new' runway. The procedure should be implemented promptly. When AFIS is provided at an aerodrome, the AFISO should timely communicate to the flight crew the runway being used at the aerodrome.

Compliance with final approach procedures. It includes but is not restricted to the following:

- According to ICAO Doc 4444, PANS ATM (PANS – Air Traffic Management)§ 4.6.3.6, '*Only minor speed adjustments not exceeding plus/minus 40 km/h (20 kt) IAS [indicated airspeed] should be used for aircraft on intermediate and final approach.*'
- According to ICAO Doc 4444, PANS ATM § 4.6.3.7, '*Speed control should not be applied to aircraft after passing a point 7 km (4 nm) from the threshold on final approach.*'
- According to ICAO Doc 4444, PANS ATM § 8.9.3.6, '*Aircraft vectored for final approach should be given a heading or a series of headings calculated to close with the final approach track. The final approach vector should enable the aircraft to be established in level flight on the final approach track prior to intercepting the specified or nominal glide path if an MLS [microwave landing system], ILS or radar approach is to be made, and should provide an intercept angle with the final approach track of 45 degrees or less.*'
- **NOTE**: T*he flight crew has a requirement to fly a stabilised approach (airspeed and configuration) typically by 5 km (3 nm) from the threshold (Doc 8168, PANS-OPS, Volume I, Part III, Section 4, Chapter 3, 3.3 refers).*

- According to ICAO Doc 4444, PANS ATM in 6.7.3.2, Requirements and procedures for independent parallel approaches § 6.7.3.2.3, '*When vectoring to intercept the ILS localizer course or MLS final approach track, the final vector shall enable the aircraft to intercept the ILS localizer course or MLS final approach track at an angle not greater than 30 degrees and to provide at least 2 km (1.0 nm) straight and level flight prior to ILS localizer course or MLS final approach track intercept. The vector shall also enable the aircraft to be established on the ILS localizer course or MLS final approach track in level flight for at least 3.7 km (2.0 nm) prior to intercepting the ILS glide path or specified MLS elevation angle.*'

ILS-sensitive area during CAT II/III training approaches when LVO [low visibility operations] are not in force. Some aircraft operators conduct ILS CAT II/III approaches during non-LVO for training purposes. The presence of vehicles or aircraft in the ILS sensitive area can cause undesirable autopilot behaviour at low altitude. In addition, 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 may be requested by the aircraft operator/flight crew as advised in the aeronautical information publication (AIP). If required to protect an ILS-sensitive area, ATC may reject such a request or interrupt the current procedure according to the traffic situation at the time.

ANSP radar display marker. In some ATC facilities, controllers are provided with a 'Screen Interception Marker'. The marker arrow is displayed on the radar approach screen to support the interception of the final approach track. The marker is located in accordance with ICAO PANS ATM (so as to provide 30 seconds of straight and level flight at 180 kts). Operational procedures specify that it should be considered as the final point for the ATCO to provide a straight and level flight (Figure 5).

To complement the stabilised approach awareness training for controllers, many ANSPs utilise their routine briefing facilities (e.g., operational information folders) to highlight runway excursion prevention issues (including stabilised approaches) to controllers on a periodic basis. Further to that:

- Immediate post-runway-excursion incident/accident awareness can be provided by means of a written or oral briefing by supervisors/watch managers as part of watch handover/takeover.
- Information gathered in the context of recommendations ANSP3 and ANSP6 can also be analysed and the outcomes (e.g., lessons learnt, operational changes, etc.) notified to ATS staff through the routine briefing processes.
- ATCOs/AFISOs should be aware of the flight crew task demand and workload during the approach phase of flight. To this end, familiarisation flights and/or flight simulator sessions for ATS staff should be considered.

Figure 5. **Example the 'Screen Interception Marker' arrow (in the red circle)**

Important note. Recommendations ANSP1 and ANSP2 (and the guidance material provided above) are closely linked to the following three (3) recommendations for aircraft operators. ANSPs should also review the relevant guidance material provided in Appendix C, which contains additional information and guidance that can help achieve the objectives of recommendations ANSP1 and ANPS2.

Recommendation OPS6. Aircraft operators should implement policies for flight crews not to accept ATC procedures and clearances which have the potential to decrease safety margins to an unacceptable level for the flight crew, thereby increasing the risk of runway excursions. This includes such procedures and clearances, which increase the likelihood of having an unsafe approach path management with consequences for safe landing, e.g. which bear the risk of being unstabilised at the landing gate or high-energy approaches.

These policies should be further supplemented by the implementation of effective SOPs and flight crew training.

Flight crews should be required to report such risks within their operator's safety management system (SMS), and the aircraft operator should further report such risks to the ANSPs via established reporting systems.

Recommendation OPS8. Aircraft operators should implement SOPs or policies for flight crews not to conduct takeoff or approach following any runway change until the appropriate set-up, planning, performance calculations (for multi-pilot operations, this includes independent calculations and cross-checks by at least two pilots) and re-briefings are completed. When a takeoff runway change is received whilst taxiing, the above should be performed by flight crew without rushing and when the aircraft is stationary.

Runway-excursion related threat and error management (TEM) should be addressed in the briefing every time a runway change is expected, probable or actually occurs.

Recommendation OPS9. Aircraft operators should implement policies or SOPs for flight crews to request a more favourable runway for takeoff or landing for any reason which may affect the safety of the flight and to advise the safety reasons to ATC.

Further guidance/advice in support of the recommendations ANSP1 and ANSP2, and the points addressed in this section 1 of Appendix B, can be found in the reference materials listed below.

Reference materials

ICAO Doc 4444 - PANS ATM.

European Commission Regulation No 923/2012 on Standardised European Rules of the Air – SERA, and associated Acceptable Means of Compliance and Guidance Material.

European Commission Regulation 2017/373 on ATM/ANS Common Requirements and associated Acceptable Means of Compliance and Guidance Material.

SKYbrary resources

Stabilised Approach Awareness Toolkit for ATC;

Flight Deck Procedures – A Guide for Controllers;

Top 10 Stabilised Approach Considerations for Air Traffic Controllers; and,

Runway Excursion Portal.

CANSO,

Runway Excursions – An ATC Perspective on unstable approaches.

Avoiding unstable approaches – Important Tips for ATCOs.

DGAC, France: Three (3) documents (accessible on SKYbrary):

Unstabilised Approaches;

Synthesis on Unstabilised Approaches; and,

Stabilised Approaches Good Practice Guide.

Flight Safety Foundation (FSF) *ALAR Toolkit*, briefing notes: *4.1*, *4.2*, *7.1* and *8.1*.

FSF, *Runway Excursion Risk Awareness Tool*, May 2009.

IATA, Runway Excursion Risk Reduction Toolkit.

EUROCONTROL *HindSight 12* and *HindSight 19* magazines.

International Federation of Air Line Pilots' Associations (IFALPA) Position Paper: IFALPA Runway Safety Policy – Ref 09POS01.

Learning from data analysis and safety information exchange

Recommendation ANSP3: ANSPs should:

ANSP3 a:. Review available data (e.g., occurrence reports, go-around/missed approach data) with the aim of identifying the ANSP-related runway excursion contributing factors and relevant mitigations; for example, enhanced airspace design and procedures and ATCO/AFISO training and procedures.

ANSP3 b: Share at network level the identified runway excursion contributing factors and relevant mitigations.

Recommendation ANSP6: Participate in runway excursion safety information-sharing at network level to facilitate using just culture principles and the free exchange of relevant information on actual and potential safety deficiencies.

Why should ANSP follow the recommendations?

Accidents and incidents in the aviation industry are rare events and in order to achieve the desired further improvement in safety, it is necessary to learn from normal operations (e.g., from go-around and missed approach events). Moreover, even a large ANSP may not have sufficient information to make reliable conclusions from the investigation of reported safety occurrences. Therefore, it is important to analyse the available data from normal operations, which can reveal potential systemic contributors to runway excursions, such as airspace design and procedures (e.g., controlled airspace/sector boundaries, standard instrument arrival procedures (STARs), final approach procedures). In addition, it may be helpful for the ANSP to pool knowledge of the runway excursion risk and identify risk reduction measures based on other ANSPs' experience and lessons learnt.

In most runway excursion related events, ANSPs do not have the full picture. Therefore, it is necessary to cooperate with aircraft and aerodrome operators in order to identify all relevant causal and contributory factors and design successful risk mitigation strategies. This approach provides huge safety and economic benefits, not only for ANSPs, but also for the entire industry. It allows stakeholders that contribute to runway risk to learn from each other, understand the different perspectives of runway safety events and create a shared mental picture of the threats and hazards that pilots and air traffic controllers have to cope with in daily operation.

What can ANSP do to implement the recommendation?

Sector interfaces and the ability to control the speed and descent profiles should be taken into consideration while trying to remove or minimise airspace design contribution to excursion risk. ANSPs should consider utilising reported data from aircraft operators about unstabilised approaches in order to consider systemic changes to sector management (e.g., handover and flow rates), airspace design and associated procedures and runway configuration management to reduce the runway excursion risk. This pre-supposes that aircraft operators are willing to provide this information to ANSPs in the first instance. Cooperation through local runway safety teams (LRSTs) may assist in this regard and ANSPs can address the issue within the wider context of their SMS.

Some runway excursions can be prevented by flight crews executing a go-around when needed. Safe and timely go-arounds are dependent on two main factors: flight crew decision-making and execution. However, ATC actions can also influence both of these processes, for instance, when initiating the execution of a go-around, ATCOs should use the standard PANS ATM (12.3.4.18) phraseology, 'GO-AROUND' (flight crew response 'GOING AROUND'), and in European airspace, applicable Standardised European Rules of the Air (SERA) phraseologies, rather than alternatives such as 'break-off the approach' or 'execute missed approach,' which may lead to misunderstanding.

Some ANSPs record and then analyse go-arounds/missed approaches; any ATS contribution to unstabilised approaches may be identified qduring this process. Event replays that include surveillance information and audio recordings are another useful source of information to help ATCOs learn lessons from reported events.

Exchanging runway safety information provides significant safety benefits to all stakeholders. It allows ANSPs to learn not only from their own experiences but also from the experiences of others. Having direct contact with other stakeholders allows ANSPs to get first-hand information. It also provides an opportunity to ask specific questions and communicate on specific issues related to runway excursions without losing precious time.

ANSPs can participate in safety information sharing in several ways as part of ongoing SMS activities, such as:

- Set up safety information exchange with other ANSPs;

- Set up safety information exchange agreements with aircraft operators or other stakeholder groups;
- Register and use internet safety information exchange facilities, such as SKYbrary (www.skybrary.aero);
- Join one of the existing safety information exchange networks, such as EVAIR (EUROCONTROL Voluntary ATM Incident Reporting); IATA STEADES; Flight Safety Foundation; and,
- By being an active member of LRSTs.

***Important note:** Recommendations ANSP3 and ANSP6 (and the guidance notes provided above) are closely linked to the following recommendation for aircraft operators. ANSPs should also review the relevant guidance material provided in Appendix C, which contains additional information and guidance that can help achieve the objectives of Recommendations ANSP3 and ANSP6.*

Recommendation OPS1. Aircraft operators should participate in safety information sharing networks with all relevant stakeholders. This should facilitate the free exchange of relevant runway safety information including identified risks, safety trends and good practices.

Reference materials

European Commission Regulation No 923/2012 on Standardised European Rules of the Air – SERA, and associated Acceptable Means of Compliance and Guidance Material.

European Commission Regulation 2017/373 on ATM/ANS Common Requirements and associated Acceptable Means of Compliance and Guidance Material.

ICAO Doc 9981 Procedures for Air Navigation Services – Aerodromes.

Provision of safety critical information to flight crew

Recommendation ANSP4: Review processes covering the provision of essential information on aerodrome conditions such as weather, wind and runway surface conditions (e.g., when 'wet' or contaminated) to ensure:

ANSP4 a: A consistent, timely and accurate broadcast of aerodrome information.

ANSP4 b: The integrity of the essential information supply chain from the originator (e.g., Met Office/ aerodrome operator) to the user (e.g., flight crews, ATS, Met Office, aerodrome operator and aeronautical information service (AIS) provider).

ANSP4 c: Training on the use of ATIS/D-ATIS is provided to relevant operational staff.

ANSP4 d: Compliance with the ICAO Global Runway Format for runway surface conditions assessment and reporting, including the training of the relevant ANSP personnel.

Recommendation ANSP5:

ANSP5 a: Ensure that flight crews are informed of the takeoff run available (TORA) or the landing distance available (LDA) if these differ from the published data using appropriate means. The information should include any alternative runways, which may be available.

ANSP5 b: ATS providers should collaborate with aerodrome operators to determine the runway entries from which intersection takeoffs may be performed, and develop coordinated procedures for such operations.

Recommendation ANSP8: Consider equipping for digital transmission of ATIS, as appropriate (e.g., via telephone or other means).

Why should ANSPs follow the recommendations?

For the safe execution of approach, landing and takeoff, a flight crew relies largely on the information supplied by ATS. Provision of timely, accurate and up-to-date information about the aerodrome weather, wind, runway surface conditions and declared distances (e.g., TORA and LDA) will enable flight crew to assess correctly the situation and take safe decisions for takeoff, approach and landing or diversion to an alternate aerodrome.

Use of automated information transmission tools (e.g., ATIS, D-ATIS) increases the reliability of the information delivery process and contributes to reduced likelihood of flight crew distraction during the most critical phases of flight – approach and landing and takeoff.

What can ANSPs do to implement the recommendations?

Essential information is provided through three main types of media: (AIPs, NOTAMs); ATIS/D-ATIS; and radio telephony. In certain circumstances, aerodrome signage can supplement the written and/or oral data.

ICAO Doc 4444, PANS ATM provisions on the provision of essential information:

7.5.2 *Essential information on aerodrome conditions shall include information relating to the following:*

a) construction or maintenance work on, or immediately adjacent to the movement area;

b) rough or broken surfaces on a runway, a taxiway or an apron, whether marked or not;

c) snow, slush or ice on a runway, a taxiway or an apron;

d) water on a runway, a taxiway or an apron;

e) snow banks or drifts adjacent to a runway, a taxiway or an apron;

f) other temporary hazards, including parked aircraft and birds on the ground or in the air;

g) failure or irregular operation of part or all of the aerodrome lighting system;

h) any other pertinent information.

7.5.3 *Essential information on aerodrome conditions shall be given to every aircraft, except when it is known* *that the aircraft already has received all of or part of the information from other sources. The information shall be given in sufficient time for the aircraft to make proper use of it, and the hazards shall be identified as distinctly as possible.*

Note: *"Other sources" include NOTAM, ATIS broadcast, and the display of suitable signals.*

7.5.4 *When a not previously notified condition pertaining to the safe use by aircraft of the manoeuvring area is reported to or observed by the controller, the appropriate aerodrome authority shall be informed and operations on that part of the manoeuvring area terminated until otherwise advised by the appropriate aerodrome authority.*

It is incumbent on all personnel involved in the flow of "essential" information to ensure not only the quality of the data but also the integrity of the processes and procedures that ensure its onward transmission to ATS.

Formal arrangements between data providers and ANSP/aerodrome operators/AIS providers (e.g., in the form of a contract or service level agreement [SLA]) should be introduced to support and enable the relevant data exchange.

In turn, ATS working together with partners, should ensure the timely provision and delivery of the information to flight crews to assist in their operational decision-making.

The reception of ATIS via data link allows both pilots to listen to ATS communications during critical high workload phases of flight, thus increasing situational awareness and reducing the likelihood of distraction-induced mistakes, lapses or confusion. Furthermore, depending on the traffic density and the complexity of the approach, it may assist flight crews with the go-around/landing decision-making process by providing the latest changes to the runway condition and local weather, which is subject to the equipment being set up to allow this data to be send to the pilot automatically.

Annex 11, Air Traffic Services, Chapter 4 (Flight Information Services) states variously that ATIS/D-ATIS broadcasts shall include:

- significant runway surface conditions (e.g. when the runway is 'wet' or the presence of other contaminants such as snow, slush, ice, rubber, oil) and, surface wind direction and speed, including significant variations;
- any available information on significant meteorological phenomena in the approach and climb-out areas including wind shear, and information on recent weather of operational significance;
- "other essential operational information". Reduced runway lengths for landing and takeoff fall into this category of data.

In accordance with section 4.1.3 of Appendix 3 to ICAO Annex 3, the surface wind direction and speed is to be averaged over two minutes for wind displays in ATS units. The wind information is to refer to conditions along the runway for departing aircraft and to conditions at the touchdown zone for arriving aircraft. Specifically, according to ICAO Annex 11, Chapter 4, ATIS broadcasts shall include: '*surface wind direction and speed, including significant variations and, if surface wind sensors related specifically to the sections of runway(s) in use are available and the information is required by operators, the indication of the runway and the section of the runway to which the information refers.*'

To ensure that ATIS/D-ATIS provide operational and safety benefits, it is essential that the relevant operational AIS/ATC staff is competent to use ATIS/D-ATIS equipment and understand and apply the broad principles for the operation of these systems as described in Annex 11, Chapter 4.

ATIS/D-ATIS ***Note:*** *Depending on the organisational/operational structure, ANSPs or AISPs may be responsible for the provision of ATIS/D-ATIS.*

Weather/wind data update. According to ICAO Doc 4444 – PANS ATM, paragraph 6.6.4:

At the commencement of final approach, the following information shall be transmitted to aircraft:

a) Significant changes in the mean surface wind direction and speed;

Note. Significant changes are specified in Annex 3, Chapter 4. However, if the controller possesses wind information in the form of components, the significant changes are:

- *Mean headwind component: 19 km/h (10 kt);*
- *Mean tailwind component: 4 km/h (2 kt);and,*
- *Mean crosswind component: 9 km/h (5 kt).*

b) the latest information, if any, on wind shear and/or turbulence in the final approach area; and,

c) The current visibility representative of the direction of approach and landing or, when provided, the current runway visual range value(s) and the trend.

Furthermore, ICAO Annex 3, § 4.1.5.2 states that wind gusts of 5 kts or more above the mean wind speed shall be reported when noise abatement procedures are in force, otherwise wind gusts of 10 kts or more above the mean wind speed shall be reported. A wind below 1 kt will be considered as 'calm'. This information is essential to pilots in their process decision-making.

Example case study

https://www.skybrary.aero/index.php/B773,_Auckland_Airport_New_Zealand,_2007

Runway surface condition assessment and reporting. The ICAO methodology envisages:

- Assessment by trained runway assessors (aerodrome operator's personnel) and reporting — by means of a uniform runway condition report (RCR) — of the runway surface conditions, including contaminants, for each third of the runway length. This includes contaminants categorisation according to their effect on aircraft braking performance and information coding in a runway condition assessment matrix (RCAM).
- RCAM use by aircraft manufacturers to determine the appropriate performance data for specific runway surface conditions and provision of approved data and guidance material to aircraft operators for the safe operation of the aircraft on dry, wet and contaminated runway surfaces.
- Provision of the RCR information to the end users (by AIS) in an improved *SNOWTAM* form.
- Provision of the RCR information to the flight crews by ATS by means of *ATIS*, *voice communication* and *CPDLC*. The information shall be presented according to the direction of the aircraft movement, with the first runway third being the one nearest to the aircraft approaching to land.
- Use of the reported runway condition data in conjunction with the performance data provided by the aircraft manufacturer to determine — along with other information such as, but not limited to, *weather* conditions and the *weight* of the aircraft — if landing or takeoff operations can be conducted safely.
- Flight crews shall report the braking action experienced when different from the expected one.

This solution shall be applied as of 5 November 2021. In the EU, it is to be implemented as of 12 August 2021.

Runway surface condition reporting. The need to report and promulgate runway surface conditions is specified in Annex 14, Volume I, 2.9.1, which stipulates that information on the condition of the movement area and the operational status of related facilities will be provided to the appropriate AIS units, and similar information of operational significance to the ATS units, to enable those units to provide the necessary information to arriving and departing aircraft.

Currently, the primary means of communication are ATIS and ATC Radiotelephony, in addition to SNOWTAM.

In addition to normal operational and weather information in the ATIS message, the following information about the runway condition should be mentioned whenever the runway is not dry (Runway Condition Code [RWYCC] 6):

- Operational runway in use at time of issuance;
- RWYCC for the operational runway, for each runway third in the operational direction;
- Condition description, coverage and depth (for loose contaminants);
- Width of the operational runway to which the RWYCC applies, if less than the published width;
- Reduced length, if less than the published runway length;
- Drifting snow;
- Loose sand;
- Operationally significant snowbanks;
- Runway exits, taxiways and apron if POOR; and,
- Any other pertinent information in short, plain language.

One inherent weakness in the ATIS system is the currency of the information. This is because flight crews generally listen to ATIS on arrival, some 20 minutes before landing, and in rapidly changing weather, the runway conditions may alter dramatically in such a time span.

The aerodrome operator usually transmits information of operational significance relating to runway conditions to ATC, and ATC, in turn, provides this information to the flight crew if different from the ATIS. At present, this procedure appears to be the only one that is able to provide timely information to the flight crew, especially in rapidly changing conditions.

According to the ICAO Doc 9981 PANS Aerodromes, Part II:

1.1.1.8 *When the runway is wholly or partly contaminated by standing water, snow, slush, ice or frost, or is wet associated with the clearing or treatment of snow, slush, ice or frost, the runway condition report should be disseminated through the AIS and ATS services. When the runway is wet, not associated with the presence of standing water, snow, slush, ice or frost, the assessed information should be disseminated using the runway condition report through the ATS only.*

1.1.3.19 *Where available, the pilot reports of runway braking action should be taken into consideration as part of the ongoing monitoring process, using the following principle:*

- *a pilot report of runway braking action is taken into consideration for downgrading purposes; and*
- *a pilot report of runway braking action can be used for upgrading purposes only if it is used in combination with other information qualifying for upgrading.*

Note 1. *The procedures for making special air-reports regarding runway braking action are contained in the Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM, Doc 4444), Chapter 4, and Appendix 1, Instructions for air-reporting by voice communication.*

1.1.3.20 *Two consecutive pilot reports of runway braking action of POOR shall trigger an assessment if an RWYCC of 2 or better has been reported.*

1.1.3.21 *When one pilot has reported a runway braking action of LESS THAN POOR, the information shall be disseminated, a new assessment shall be made and the suspension of operations on that runway shall be considered.*

According to provision 6.6.1 of ICAO Doc 4444 – PANS ATM, ATC shall transmit to an arriving aircraft *current runway surface conditions, in case of precipitants or other temporary hazards* as early as practicable after the aircraft has established communication with the approach control unit, unless it is known that the aircraft has already received this information. Furthermore, according to provision 6.6.5 of PANS ATM, significant changes in runway surface conditions shall be transmitted without delay during final approach.

According to provision 11.4.3.4.1 of PANS ATM, information on aerodrome conditions shall be provided in a clear and concise manner so as to facilitate appreciation by the pilot of the situation described. It shall be issued whenever deemed necessary by the ATCO/AFISO on duty in the interest of safety, or when requested by an aircraft. If the information is provided on the initiative of the ATCO/AFISO, it shall be transmitted to each aircraft concerned in sufficient time to enable the pilot to make proper use of the information.

Phraseology. The following phraseology provided in Doc 4444 PANS ATM shall be used for provision of aerodrome information:

a) [(location)] RUNWAY (number) SURFACE CONDITION [CODE (three-digit number)], followed as necessary by:

1) ISSUED AT (date and time UTC);

2) DRY, or WET ICE, or WATER ON TOP OF COMPACTED SNOW, or DRY SNOW, or DRY SNOW ON TOP OF ICE, or WET SNOW ON TOP OF ICE, or ICE, or SLUSH, or STANDING WATER, or COMPACTED SNOW, or WET SNOW, or DRY SNOW ON TOP OF COMPACTED SNOW, or WET SNOW ON TOP OF COMPACTED SNOW, or WET, or SLIPPERY WET or SPECIALLY PREPARED WINTER RUNWAY or FROST;

3) DEPTH ((depth of deposit) MILLIMETRES or NOT REPORTED);

4) COVERAGE ((number) PER CENT or NOT REPORTED);

5) ESTIMATED SURFACE FRICTION (GOOD, or GOOD TO MEDIUM, or MEDIUM, or MEDIUM TO POOR, or POOR, or LESS THAN POOR);

6) AVAILABLE WIDTH (number) METRES;

7) LENGTH REDUCED TO (number) METRES;

8) DRIFTING SNOW;

9) LOOSE SAND;

10) CHEMICALLY TREATED;

11) SNOWBANK (number) METRES [LEFT, or RIGHT, or LEFT AND RIGHT] [OF or FROM] CENTRELINE;

12) TAXIWAY (identification of taxiway) SNOWBANK (number) METRES [LEFT, or RIGHT, or LEFT AND RIGHT] [OF or FROM] CENTRELINE;

13) ADJACENT SNOWBANKS;

14) TAXIWAY (identification of taxiway) POOR;

15) APRON (identification of apron) POOR;

16) Plain language remarks.

b) [(location)] RUNWAY SURFACE CONDITION RUNWAY (number) NOT CURRENT;

c) LANDING SURFACE (condition);

d) CAUTION CONSTRUCTION WORK (location);

e) CAUTION (specify reasons) RIGHT (or LEFT), (or BOTH SIDES) OF RUNWAY [(number)];

f) CAUTION WORK IN PROGRESS (or OBSTRUCTION) (position and any necessary advice);

g) BRAKING ACTION REPORTED BY (aircraft type) AT (time) GOOD (or GOOD TO MEDIUM, or MEDIUM, or MEDIUM TO POOR, or POOR);

h) TAXIWAY (identification of taxiway) WET [or STANDING WATER, or SNOW REMOVED (length and width as applicable), or CHEMICALLY TREATED, or COVERED WITH PATCHES OF DRY SNOW (or WET SNOW, or COMPACTED SNOW, or SLUSH, or FROZEN SLUSH, or ICE, or WET ICE, or ICE UNDERNEATH, or ICE AND SNOW, or SNOWDRIFTS, or FROZEN RUTS AND RIDGES or LOOSE SAND)];

i) TOWER OBSERVES (weather information);

j) PILOT REPORTS (weather information).

Note: *The terms SLIPPERY WET and SPECIALLY PREPARED WINTER RUNWAY are used in the EU.*

Pilot report of runway braking action. The braking action observed by the pilot depends on the type of aircraft, aircraft weight, runway portion used for braking and other factors. Pilots will use the terms GOOD, GOOD TO MEDIUM, MEDIUM, MEDIUM TO POOR, POOR and LESS THAN POOR.

When receiving a routine pilot report of in-flight weather conditions (AIREP), the ATCO/AFISO should consider that these terms rarely apply to the full length of the runway and are limited to the specific sections of the runway surface in which sufficient wheel braking is applied. Since AIREPs are subjective and contaminated runways may affect the performance of different aircraft types in different ways, the reported braking action may not be directly transferable to another aircraft.

If an ATS unit (e.g., ATC tower) receives an AIREP by voice communications concerning braking action that is found not to be as good as that reported, ATCO/AFISO shall forward the AIREP without delay to the aerodrome operator. This is a prerequisite for using the AIREP for downgrading purposes when assessing the RWYCC.

ANSPs and aerodrome operators shall have coordinated (e.g., by means of an SLA) operating procedures for the distribution of AIREPs to aerodrome operators.

Radio Telephony. Time-critical aerodrome information (such as weather, surface conditions, wind, etc.) that may affect runway operations shall be provided to pilots in 'real time' using radiotelephony communication.

Use of 'non-essential' information. ATCOs/AFISOs should understand that some well-intentioned actions, clearances and instructions, or information passed to flight crews to improve the flow of air traffic may not always have the planned consequences. For instance, using phrases such as 'landing long available' might induce pilots to touchdown further down the runway than they had originally intended/calculated. Furthermore, depending on flight crew experience and constraints, the surface conditions and the time/position in the landing sequence where the manoeuvre is executed, the use of 'expedite vacate' may trigger pilots to travel too fast for the conditions and/or aerodrome layout. Of course, in many situations, the use of these phrases may be perfectly legitimate (and safe). Nevertheless, to lessen the risk of runway excursion, controllers should use them with care. The timing of the messages is a key consideration, and they should be used only in circumstances that are appropriate to the prevailing runway surface conditions and/or aerodrome layout.

Declared distances. ICAO Annex 14, Aerodromes, §2.8 requires that distances shall be calculated to the nearest metre or foot for a runway intended for use by international commercial air transport. These 'declared distances' include: takeoff run available (TORA); takeoff distance available (TODA); accelerate-stop distance available (ASDA); and landing distance available (LDA).

Note*: Guidance on calculation of declared distances is given in Attachment A, Section of ICAO Annex 14 and in local rules, where available.*

TORA and LDA for a particular runway may vary from those published for a variety of reasons (e.g., construction work or snow clearing operations, which may reduce the takeoff and landing distances available). This 'essential information' must be made available to flight crews via an appropriate mechanism and format, in accordance with ICAO Annex 15, Aeronautical Information Services, ICAO Doc 4444 PANS ATM and ICAO Doc 10066 PANS AIM. In addition, the temporary reduction of the 'declared distances' should be included in the ATIS messages. Nonetheless, ATS may also consider it appropriate to provide this information in 'real-time,' even when the changes have been notified in aeronautical publications and/or ATIS/D-ATIS. At aerodromes, where ATIS is not available, ATS should proactively inform the flight crew by means of a radiotelephony (R/T) exchange of the reduced takeoff and landing distances available.

Intersection departures. Flight crews may opt for, or ATS may suggest, a departure from a runway intersection that effectively reduces the runway length available for flight operations. Intersection departures should be appropriate to the aircraft type and take into account work in progress and other relevant factors limiting operations.

ATS should provide alternative runway(s) to the assigned intersection runway in case the flight crew report not able to perform a takeoff from the assigned intersection.

The ultimate decision regarding intersection departure rests with the flight crew; however, ATC actions assist in the decision-making process. To ensure that the intersection TORA distances are known, ATS should inform pilots of the takeoff run available (in metres) from the runway intersection position if this differs from the signage.

According to ICAO Doc 7030, European Regional Supplementary (EUR SUPPs) § 6.5.2.4, '*Runway declared distances for an intersection take-off position shall be published in the relevant AIP, clearly distinguishable from full runway declared distances*'.

Best practice exists concerning the associated phraseology to be used by ATS, which is in line with the guidance in the ICAO EUR SUPPs, namely:

- 'TORA' (to be pronounced as 'TOR-AH') replaces the words 'TAKEOFF' in the R/T message.
- Thus, an example ATC R/T message to advise of the takeoff run available from an intersection will be: 'Call sign, Tora runway 09, from intersection alpha, 2800 metres'.

When an ANSP plans for intersection departure procedures, the development of these procedures should be coordinated with the aerodrome operators. This is to ensure that the procedures of both organisations do not contain inconsistencies or discrepancies and that they take into account operational needs and limitations, especially with regard to the interfaces of the two organisations, irrespective of how they are organised internally. In the EU, from an ATM point of view, this recommendation is based on the requirement ATS.OR.110 contained in Reg. (EU) 2017/373 (as amended by 2020/469). It says, 'An air traffic services provider shall establish arrangements with the operator of the aerodrome at which it provides air traffic services to ensure adequate coordination of activities and services provided as well as exchange of relevant data and information'.

Example case study

https://www.skybrary.aero/index.php/B772,_St_Kitts_West_Indies,_2009

To supplement the oral message, ICAO Annex 14, Aerodromes, recommends that an intersection takeoff sign should be provided when there is an operational need to indicate the remaining TORA for an intersection takeoff. In addition, according to provision 5.4.3.29 of Annex 14, Volume I, *'the inscription on an intersection take-off sign shall consist of a numerical message indicating the remaining take-off run available* *in metres plus an arrow, appropriately located and oriented, indicating the direction of take-off…'.*

The GAPPRE recommendation ADR4 takes the above Annex 14 provision further by recommending provision of takeoff run available (TORA) signs at all runway holding positions from which intersection takeoffs are conducted.

In the EU, the installation of an intersection takeoff sign, indicating the remaining takeoff run available (TORA), is considered a prerequisite wherever intersection takeoffs are allowed

ANSPs should cooperate with aerodrome operators to clarify the signage requirements on individual aerodromes.

Construction/Work in Progress. The runway length available for takeoff or landing may change during construction or other work in progress. If the revised runway lengths available (TORA/LDA) differ from published data, the revised TORA/LDA should be made available by the aerodrome operator to flight crews via changes to the AIP and/or NOTAM. ATIS/D-ATIS (data link ATIS) should also be used to re-enforce the message.

For short-notice reductions when the necessary aeronautical information amendments have not been promulgated, it is important to clearly state that the TORA/LDA is different from published and it will be necessary for ATS to broadcast the essential information via R/T and/or ATIS/D-ATIS. In addition, ATS may also consider it appropriate to provide this information in 'real-time' even when the changes have been notified in aeronautical publications and/or ATIS/D-ATIS.

ICAO Doc 4444, PANS ATM, Phraseologies § 12.3.1.10 provides the phraseology to be used by ATCO to notify the flight crew of on-going construction work:

- CAUTION CONSTRUCTION WORK (location);
- CAUTION (specify reasons) RIGHT (or LEFT), (or BOTH SIDES OF RUNWAY [Number]); and,
- CAUTION WORK IN PROGRESS (or OBSTRUCTION) (position and any necessary advice).

Example case study

https://www.skybrary.aero/index.php/B738,_Manchester_UK,_2003

https://www.skybrary.aero/index.php/DH8D,_Chania_Greece,_2010

Landing distances. With regard to reduced landing distances (displaced threshold), Annex 14, Attachment A, §3.5 states: *'Where a runway has a displaced threshold, then the LDA will be reduced by the distance the threshold is displaced. … A displaced threshold affects only the LDA for the approaches made to that threshold; all declared distances for operations in the reciprocal direction are unaffected.'*

Reference materials

ICAO Annex 3, Meteorological Services for International Air Navigation.

ICAO Annex 11, Air Traffic Services.

ICAO Annex 14, Aerodromes.

ICAO Annex 15, Aeronautical Information Services.

ICAO Doc 4444 – PANS ATM.

ICAO Doc 10066 – PANS AIM.

ICAO Doc 9981 – PANS Aerodromes.

ICAO Doc 7030, Regional Supplementary Procedures (Europe).

ICAO Doc 9432, Manual of Radiotelephony.

ICAO Circular 355 - Assessment, Measurement and Reporting of Runway Surface Conditions.

European Commission Regulation No 923/2012 on Standardised European Rules of the Air – SERA, and associated Acceptable Means of Compliance and Guidance Material.

European Commission Regulation 2017/373 on ATM/ANS Common Requirements and associated Acceptable Means of Compliance and Guidance Material.

European Commission Regulation (EU) No 139/2014 – Aerodromes, and associated Acceptable Means of Compliance, Certification Specifications and Guidance Material.

EASA SIB No 2018-02: *Runway Surface Condition Reporting*, 18 January 2018.

EASA SIB No 2015-25: *Publication of declared distances for runways where intersection take-offs take place,* 18 November 2015.

FAA *AC 150/5200-30D: Airport Field Condition Assessments and Winter Operations Safety*, of 29 October 2020.

RCAM Braking Action Codes and Definitions for Pilots, AC 91-79A CHG1 Appendix 1, April 2016.

Flight Safety Foundation (FSF) *ALAR Toolkit*, briefing notes: *8.1*, *8.3*, *8.5*, *8.6* and *8.7*.

Correct alignment on the runway

Recommendation ANSP7: If installed, runway centreline lights should also be used together with the runway edge lights whenever runway edge lights are switched on and when the runway is in use.

Why should ANSPs follow the recommendations?

The runway edge lights provide an overall perspective to both landing and taking off aircraft. This is enhanced by the centreline lights that provide information to the flight crew by supporting better alignment on the runway centreline and by providing information about the remaining runway distance by means of alternate red and white lights, where implemented.

The runway centreline lights could help prevent aircraft from lining up for departure with the edge lights, while they provide valuable visual cues for landing aircraft, too.

What can ANSPs do to implement the recommendation?

Runway centreline lights are usually installed on precision CAT II/III approach runways to facilitate landing under adverse visibility conditions. They are located along the runway centreline and are normally spaced at approximately 15 m (50-foot) intervals. When viewed from the landing threshold, the runway centreline lights are white until the last 3,000 feet (900 m) of the runway. The white lights begin to alternate with red for the next 2,000 feet (600 m), and for the last 1,000 feet (300 m) of the runway, all centreline lights are red.

ICAO Annex 14, § 5.3.12.2 recommends also that '*Runway centre line lights should be provided on a precision approach runway category I, particularly when the runway is used by aircraft with high landing speeds or where the width between the runway edge lights is greater than 50 m.*' In addition, Annex 14 § 5.3.12.4 recommends that *'Runway centre line lights should be provided on a runway intended to be used for takeoff with an operating minimum of an RVR of the order of 400 m or higher when used by aeroplanes with a very high takeoff speed, particularly where the width between the runway edge lights is greater than 50 m.'*

Typically, all lights are controlled by the ATC tower, a flight service station or another designated authority. This also avoids the cost of having the lighting system on for extended periods.

Use of the runway centreline lights along with the runway edge lights will, on the one hand, support the correct runway visual acquisition and positioning by flight crew and reduce the likelihood of wrong aircraft alignment on the runway or on the wrong runway or on a taxiway; and on the other hand, it will provide for better alignment with the runway centreline during landing operations.

Important note: *Recommendation ANSP7 and the guidance notes provided above are closely linked to the following recommendation for aerodrome operators. ANSP should also review the relevant guidance material provided in Appendix B, which contains additional information and advice that can help achieve the objectives of recommendation ANSP7.*

Recommendation ADR10. If installed, runway centreline lights should also be used together with the runway edge lights whenever runway edge lights are switched on and when the runway is in use.

References

ICAO Annex14, Volume 1 'Aerodrome Design and Operations'.

ICAO Doc 9157 'Aerodrome Design Manual Part 4, Visual Aids', chapter 16.

ICAO Doc 4444 PANS-ATM, Chapter 7.

UK CAA, *CAP 637 Visual Aids Handbook* (2007).

ICAO Runway Excursion Risk Reduction Toolkit - Aerodrome Best Practice (2nd edition).

ACRP Report 148: LED Airfield Lighting System Operation and Maintenance, J. Burns et al., Transportation Research Board (U.S.), 2015.

https://www.skybrary.aero/index.php/Runway_Lighting.

European Commission Regulation 2017/373 on ATM/ANS Common Requirements and associated Acceptable Means of Compliance and Guidance Material.

European Commission Regulation (EU) No 139/2014 – Aerodromes, and associated Acceptable Means of Compliance, Certification Specifications and Guidance Material.

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APPENDIX C
GUIDANCE AND EXPLANATORY MATERIAL FOR AIRCRAFT OPERATORS

1 Glossary

ASIAS	Aviation Safety Information Analysis and Sharing
ATC	Air traffic control
ATCO	Air traffic controller
ANSP	Air navigation service provider
CDO	Continuous descent operation
EASA	European Aviation Safety Agency
EBAA	European Business Aviation Association
ERA	European Regions Airlines Association
EOFDM	European Operators Flight Data Monitoring Forum
EOSID	Engine-out standard instrument departure
EVAIR	EUROCONTROL voluntary ATM incident reporting
FAA	Federal Aviation Administration
FMC	Flight management computer
FSF	Flight Safety Foundation
GRF	Global Reporting Format
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IDX	Incident Data eXchange (IATA)
ILS	Instrument landing system
LDA	Landing distance available
LDA	Low drag approach
LOFT	Line-oriented flight training
LOSA	Line Operations Safety Audit
LPV	Localiser performance with vertical guidance
MRVA	Minimum Radar Vectoring Altitude
MTOW	Maximum takeoff weight
OAT	Outside air temperature
OPC	Operator proficiency check
RAAS	Runway Awareness and Advisory System
RCC	Runway condition code
RNP	Required navigation performance
ROAAS	Runway Overrun Awareness and Alerting System
RTO	Rejected takeoff
PF	Pilot flying
PIREP	Pilot report
PM	Pilot monitoring
PIC	Pilot in command
SIC	Second in command (Copilot)
SID	Standard instrument departure
SMS	Safety management system
SOP	Standard operating procedure
STAR	Standard arrival route
TEM	Threat and error management
TOW	Takeoff weight

2 General considerations for aircraft operators

Each aircraft operator is invited to review and prioritise the proposed recommendations. The following guidance material is provided to assist with implementation.

2.1 Collaboration with other industry stakeholders/safety information sharing (OPS 1)

Recommendation OPS 1: Aircraft operators should participate in safety information sharing networks with all relevant stakeholders. This should facilitate the free exchange of relevant runway safety information including identified risks, safety trends and good practices.

Why should aircraft operators follow this recommendation?

In order to effectively prevent runway safety events, it is necessary that all stakeholders in aviation work together and exchange safety-relevant information. This allows aircraft operators and other stakeholders to learn from each other, understand different perspectives and create a shared mental picture of the threats and hazards that flight crews and air traffic controllers have to cope with in daily operation.

Aircraft operators have the best source of information available to gain knowledge about what works well and what needs improvement in order to mitigate runway excursion risks in daily operation — the flight crews. Aircraft operators can actively encourage flight crews to report not only occurrences but also their experiences in routine operation, both positives and negatives (e.g., on approach path management, traffic spacing or actual braking action at an airport during wet runway operation).

By exchanging safety reports and information about their safety risk areas with other aircraft operators, airports and air navigation service providers (ANSPs), aircraft operators might even be able to receive additional relevant information on top of what their flight crews experience, making them aware of hazards which would otherwise be hidden to them. Being proactive in safety information sharing can help the whole industry to become preventative in runway excursion risk reduction.

What can aircraft operators do to implement the recommendation?

In order to build or receive the required level of trust needed to establish a safety information exchange with other aircraft operators or other industry stakeholders, aircraft operators should consider the following steps:

- Aircraft operators should be proactive in establishing professional contacts between the safety, flight operations and training departments of their organisation and those of other industry stakeholders such as ANSPs and other aircraft operators. Professional contacts and direct cooperation will help to build trust and will enable the flow of safety-relevant information.
- Aircraft operators should include their senior and board management as well as communication departments in the process of setting up safety information-sharing networks in order to increase their understanding of how the benefits of such exchange outweighs the manageable risks of reputational problems, especially as safety information exchange does not only include negative events but positive ones as well. If necessary, consider setting up formal agreements for the exchange of sensitive information.
- Aircraft operators should make it as easy as possible to allow external stakeholders direct safety reporting of relevant safety events or safety risk areas into their safety management systems (SMS) (e.g., by proactively promulgating the relevant email address or website information), while at the same time requesting the relevant addresses from the others to enable communication between the SMS on specific issues without losing precious time and to get first-hand information on relevant safety topics. (See *OPS 6*.)
- Aircraft operators should consider proactively distributing their safety newsletter or magazine to other industry stakeholders and promulgating relevant information received via safety information-sharing networks to their flight crews to enhance their awareness on industry safety issues and encourage their own safety reporting.
- Aircraft operators should consider registering or joining existing safety information-sharing networks or relevant organisations, which are currently the following:
  - European Union Aviation Safety Agency (EASA) Data4Safety;
  - European Operators Flight Data Monitoring (EOFDM);
  - U.S. Federal Aviation Administration (FAA) Aviation Safety Information Analysis and Sharing (ASIAS);
  - SKYbrary;
  - Flight Safety Foundation;
  - European Regions Airline Association;
  - International Air Transport Association (IATA) (Flight, Incident and Accident Data eXchange (FDX, IDX and ADX);
  - Local runway safety teams (LRST);
  - Eurocontrol Voluntary Air Traffic Management (ATM) Incident Reporting (EVAIR); and,
  - European Business Aviation Association (EBAA).

2.2 Aircraft operator's safety culture (OPS 29)

Recommendation OPS 29: Aircraft operators should foster a culture that stimulates safe behaviour, which in turn encourages risk-averse decision-making by flight crews.

Why should aircraft operators follow this recommendation?

Many runway excursion events happen in normal operation, meaning with technically fully operational aircraft and without any (impending) abnormal or emergency situation, and are caused by flight crews' mismanagement of threats. However, these human failures often originate from organizational and operational pressures flight crews face in their daily operation. It is therefore of utmost importance that flight crews feel psychologically safe to always behave in a risk-averse (i.e., defensive/conservative) manner with regard to their safety-relevant decision-making. This includes feeling free to intervene, for example, within their flight crew or toward their operations control and air traffic control (ATC), if required. For this, flight crews need the backing of their aircraft operator as an employer, which should make clear to them that such risk-averse behaviour is not only tolerated but explicitly expected and encouraged.

Always prioritising safety over efficiency, and thereby being risk-averse, is the ultimate tool which flight crews have in daily operation to prevent complex and error-prone situations, to always work as intended and to deal safely with all threats on their flights. Especially for the prevention of runway excursions, this includes, but is not limited to:

- Taking the time needed to perform aircraft performance calculations and doing pre-departure or approach set-up/briefings in a calm and thorough manner, even if this causes delay or holding; and,
- Performing a missed approach whenever not stabilised on approach or reduce wind limits (see *OPS 11*), depending on the flight crew's experience, proficiency or fatigue level, even if this leads to a diversion.

There are many more examples reflecting the need for a psychologically safe environment which flight crews need to ensure safe flights. Because individual pilots may have differing risk perceptions and risk appetites, there is an additional need to clarify that effective prevention of unsafe events requires safe (team) decision-making, meaning that the more risk-averse (that is, the more defensive or conservative) option will always be preferred as demanded by any of the pilots in a flight crew, irrespective of rank or experience.

What can aircraft operators do to implement the recommendation?

As set out by the structure of an aircraft operator's SMS, the safety policy, whether standing alone or incorporated into other policy texts, is the highest-ranking policy in the organisation, governing all of their activities and those of their employees. Writing and formulating this policy in such a way as to leave no doubt to anyone that aircraft operators expect everyone in their organisation to always prioritise safety over efficiency, even if this means accepting financial losses or delay, will create a common baseline for their operations. Although a SMS looks for a balance between safety and efficiency using risk management principles, it has to be made clear, especially to the frontline staff, that their duty is to always prioritize safety over efficiency in order to ensure safety and, in this context, to prevent runway excursions.

The following passages might serve as a guideline for a wording of such a policy:

> *'Safety is our most important business function as (airline/organisation) highly depends on safe and reliable operation. All levels of management and all employees are responsible for the delivery of the highest level of safety performance, starting with me, the (accountable manager/CEO). The adherence to these standards is more important than economic or other matters. To achieve these standards, I (accountable manager/CEO) will support the management of safety through the implementation of all necessary measures and the provision of all financial, material and human resources which are required for safe day-to-day operation. This will result in an organisational culture that fosters safe practices and encourages or even rewards open and effective safety reporting and communication.'*

> *'Our mutual goal shall be to apply our "Safety First" principle in our strategic and day-to-day decision-making and to manage safety in a proactive and systematic manner in order to ensure an always efficient, reliable and resilient operation of (airline/organisation) and its related activities. You and I can contribute to this by learning from our mistakes; sharing best practices; reporting hazardous or unsafe situations or problems; applying critical thinking with regard to our policies, standards and procedures; and reporting any possibility for improvement via our established reporting systems.'*

Writing policies alone will be insufficient to foster the required culture. However, by exemplifying these values and educating and training their flight crews on how to meet this common standard, aircraft operators will create the work environment required to make it easy for their flight crews to deal safely with all everyday threats and effectively prevent runway excursions. Furthermore, aircraft operators can convey a positive message to foster safe behaviour by presenting good examples of safe decision-making in their safety promotion (e.g., the effective intervention by a pilot monitoring (PM) on an unstable approach leading to a go-around. Aircraft operators can even choose to reward pilots directly for positive safety behaviour.

2.3 Training flight crews in preventing runway excursions (OPS 3)

Recommendation OPS 3: Aircraft operators and training providers should include realistic, evidence- and competency-based scenarios in their training programmes requiring threat and error management for runway excursion prevention during both takeoff and landing. This should include evidence- and competency-based recurrent simulator training programmes which are representative in terms of environmental conditions, including crosswinds, landing on contaminated/slippery runways and poor visibility adapted with simulator representativeness. Representativeness of simulators should be assessed and their limitations communicated (in order to avoid negative training).

Why should aircraft operators follow this recommendation?

Runway excursions can happen during takeoff or landing. There can be overruns or veer-offs, on both takeoff or landing, after or during a non-normal situation (e.g., a takeoff abort or a brake failure upon landing). They can also happen in normal operation owing to flight crews' mismanagement of flight-related threats. The prevention of runway excursions requires a holistic approach towards pilot training covering both pilot's technical and non-technical competencies as well as the promotion of a safety-oriented company culture throughout the training. In order to effectively prevent runway excursions, flight crews need training which increases their confidence in handling their aircraft safely, even in demanding and complex situations (e.g., in gusty crosswinds). It is also important that they require training in how to safely manage threats and hazards as a team without using up their own and their team members' safety margins. Runway excursion prevention training therefore requires special emphasis on team decision-making and effective monitoring and intervention, including safely taking away control by the PM in complex situations, if required, irrespective of considerations of rank or experience.

What can aircraft operators do to implement the recommendation?

Flight operations, crew training and safety departments should develop common strategies to address the issue of runway excursion prevention. The aircraft operator's SMS can deliver case studies and insights from investigations. The training department can use those for building effective lesson plans both for their simulator and crew resource management/threat and error management (CRM/TEM) and accident prevention trainings. This should also bear in mind the necessity for appropriate presentation of the cases in order to avoid negative training. The flight operations department can use the training feedback to critically reassess their policies and standard operating procedures (SOPs). Additionally, the safety promotion part of the SMS can be used to distribute data and raise flight crews' awareness of the prevention of runway excursions. Lessons learned from past incidents or accidents can easily be distributed using safety promotion tools (e.g., internal safety journals, email briefings, memos).

Flight crew training for runway excursion prevention should include, among other things:

- Train flight crews in takeoff and landing performance calculation and assessment (See *OPS 29* and *OPS 13*);
- Expose flight crews to changing weather situations in simulator missions which require recalculations and/or changes to previous decisions (e.g., increasing tailwind requiring a change of runway direction);
- Train flight crews in takeoff decision-making, including simulator scenarios which help to establish resilience to startle during takeoff (e.g., when dealing with loud tyre bursts, engine stalls) (See *OPS 14*);
- Train flight crews in recovering the descent profile safely (e.g., resulting from late descent clearances);
- Train flight crews in ways to increase the descent distance with ATC (e.g., by using intervention wordings like 'unable' or requesting appropriate mileage) (See *OPS 9*, *OPS 7*, *OPS 19*);
- Train flight crews in go-around decision-making and execution in various situations, including early or late go-arounds on approach or landing (even during flare and touchdown) (See *OPS 16*);
- Train flight crews in effective monitoring and intervention, including safely taking away control from the pilot flying (PF) by the PM, if required, irrespective of rank or experience (See *OPS 19*);
- Brief flight crews on how simulator representativeness regarding aircraft behaviour, fault generation or environmental conditions may restrict or influence the training objective with regard to runway excursion prevention (e.g., differing simulator crosswind behaviour, restrictions in simulating brake failures or different runway contamination or slipperiness) in order to avoid negative training; and
- Highlight the availability of aircraft arresting systems such as engineered materials arresting systems (EMAS), if available.

In the event that aircraft operators outsource such training to a training provider, they should make sure that the training methods and scenarios used fulfil their needs with regard to runway excursion prevention training. In general, aircraft operators should rethink the amount and structure of their flight crew training for preventing runway excursions. Complying only with the minimum legal requirements in terms of the amount and frequency of simulator events for flight crews might not be sufficient to compensate for a possible reduction in flight crews' manual flying skills owing to today's increased use of automation. Training flight crews regularly and thoroughly in flying stabilised approaches and landings in demanding weather situations such as changing or gusty (cross)winds, low ceiling/visibility or turbulence conditions and using different levels of automation (with or without flight director guidance), including manually flown go-arounds, might be worth considering for maintaining and possibly improving flight crews' ability to effectively prevent runway excursions.

2.4 Dealing safely with challenging ATC clearances (OPS 6)

Recommendation OPS 6: Aircraft operators should implement policies for flight crews not to accept ATC procedures and clearances which have the potential to decrease safety margins to an unacceptable level for the flight crew thereby increasing the risk of runway excursions. This includes such procedures and clearances which increase the likelihood of having an unsafe approach path management with consequences for safe landing, e.g. which bear the risk of being unstabilised at the landing gate or high-energy approaches. These policies should be further supplemented by the implementation of effective SOPs and flight crew training.

Flight crews should be required to report such risks within their operator's SMS and the aircraft operator should further report such risks to the ANSPs via established reporting systems (see Recommendation *OPS 1*).

Why should aircraft operators follow this recommendation?

The aviation industry is a complex sociotechnical system of which aircraft operators and ANSPs are equal parts. Both entities, and thereby, their management and staff, have the primary duty to ensure safe flights. This mutual goal, and especially the effective prevention of runway excursions, can only be achieved if flight crews and air traffic controllers (ATCOs) prioritise safety over efficiency in their daily operation, meaning that they are always TETO[1]-minded and aim to operate with adequate safety margins.

However, there might be situations in which flight crews and ATCOs have different perspectives on the safety margin actually needed, leading to a different perception of what is safe and what is not. While flight crews cannot have a global picture of the collision risk with other traffic, especially in crowded airspace, ATCOs cannot have the full picture of the threats which flight crews have to cope with on the flight deck. For instance, applying minimum separation only or vectoring an aircraft along a regularly used descent profile does not necessarily guarantee that this separation or this vectoring is always safe. There may be individual threats to a flight which are invisible to ATCOs but visible to the flight crews, who might therefore require more safety margins than the ATCOs would expect. This could be flight crew fatigue, lack of proficiency or training, changing winds aloft leading to a reduced speed-reduction capability, or aircraft-type-related threats, like gross weight or performance limitations. Thereby, flight crews are often confronted with ATC clearances or instructions which they are not comfortable with. Examples of this are:

- A tight base-turn;
- An instruction to keep the speed up;
- Late descent clearance;
- Requests to expedite vacating the runway;
- Requests for immediate/rolling takeoffs;
- Late runway changes, on both takeoff or landing;
- Late handing over from approach to tower (<9 nm final);
- Instructions to increase the rate of descent and reduce the speed at the same time; and,
- Instructions for an early level-off, on both takeoff or go-around.

These clearances are often well intentioned but do not always take into consideration the high workload and complexity they pose to the flight crew during the last minutes of the flight. They might even lead flight crews to accept a clearance which will make the safe operation of the aircraft a challenge.

Flight crews should be encouraged to intervene and reject such challenging clearances (e.g., by using the wording 'unable'). Nevertheless saying 'no' or 'unable' might be a highly difficult and demanding task for flight crews, if they do not feel psychologically safe to do so. There are many different reasons for this:

- Flight crews do not know that they are 'allowed' to refuse an instruction;
- Flight crews might not realise which situation they are being pushed into;
- Flight crews do not want to offend the controller by refusing the instruction;
- Flight crews fear reprisal either from aircraft operators or ATC;

[1] TETO – Thoroughness Efficiency Trade Off (the opposite of ETTO – Efficiency Thoroughness Trade Off) – see *https://www.skybrary.aero/index.php/Toolkit:Systems_Thinking_for_Safety/Principle_7._Trade-offs*

- Cultural issues might give the ATC instruction the status of an 'order';
- There may be felt or real commercial pressure to accept 'shortcuts';
- The deviation has become the standard;
- Status hierarchy effects on the flight deck; and,
- Lack of intervention/assertiveness training.

The same applies, of course, to ATCOs, who should also have the possibility and backing by their management to always reject any unacceptable request by flight crews and even challenge and intervene in flight crews' flight path management if it is deemed too risky by the ATCO. This mutual intervention and concept of 'prevention by intervention' needs to be accepted by the ANSPs and the aircraft operators. There should be consensus in our industry that the more defensive and conservative (i.e,. more risk-averse) option should always be that preferred in a given situation, irrespective of whether demanded by flight crews or ATCOs.

Especially for ATC, it is important to understand that aircraft operators expect their flight crews to always adhere to stabilised approach criteria or be risk-averse in their safety-relevant behaviour, which might require them to refuse ATC clearances. Having a written official policy and related SOPs in their documentation gives flight crews and the persons in contact with the ANSPs (e.g., safety staff during meetings with local runway safety teams) sufficient arguments and backing to promote a common risk perception of flight crews and ATCOs in daily operation. Furthermore, such interchange of arguments might even provide aircraft operators with the opportunity to critically reassess their own flight procedures and learn from others.

Meetings with the ANSP (e.g., those attended by your safety department staff in local runway safety teams) are a proactive way of increasing understanding of each other. The knowledge gained during these meetings should be disseminated to all crews to raise their awareness of the matters discussed. This will enable crews to know about safety issues at different locations and thus be prepared for the 'unexpected'. Furthermore, aircraft operators can put in place an exchange programme between ANSPs and aircraft operators. This means that controllers will be allowed to conduct familiarisation flights in the flight deck or in a flight simulator and that flight crews will visit the ANSP facilities. This will help to improve their understanding of each other's work constraints.

In the scope of their respective SMS, it is important that flight crews and ATCOs understand the importance of reporting any issue with challenging clearances or requests which reduce or eliminate required safety margins in daily practice. Safety departments will need data in order to be able to address such issues so that both groups can mutually learn from each other and so that hazards or negative trends can be identified and acted on early.

What can aircraft operators do to implement the recommendation?

An aircraft operator's duty is to make clear to all their flight crews via policies, SOPs and training that they are allowed to reject any ATC instruction which may create an unsafe situation. Their flight crews need to understand that they are ultimately responsible for the safe operation of their aircraft in its entirety, while ATCOs are only responsible for the safe separation of traffic in their individual airspace. The following should be considered when establishing such policies, SOPs and training practices:

- Aircraft operators should provide their flight crews with documented tools (e.g., procedures describing when and how to use wordings like 'unable'), which may help them to overcome psychological barriers for intervention, as mentioned above. When formulating procedures, make it clear that the decision to refuse a clearance should be communicated as soon as possible to allow the ATCO to review his/her traffic sequencing. Reference for such tools can be taken from already established best practices (e.g., as outlined in the Civil Air Navigation Services Organisation (CANSO) paper with important tips for pilots and ATCOs, or IATA's paper on unstable approaches.)[2]
- Aircraft operators should consider restricting high speed flying (>250 kts) below Flight Level (FL) 100, except for non-normal or emergency situations.
- Aircraft operators should incorporate ATC intervention scenarios in their simulator programme and during CRM/TEM/accident prevention courses.
- Aircraft operators should require their flight crews to proactively provide hazard reports about potentially unsafe departure or approach procedures as well as challenging ATC clearances in order to gain knowledge about affected airports in their route network. These reports should also be used to inform all of their flight crews about issues with challenging ATC clearances via their airport briefings or similar means. Additionally, aircraft operators should get in contact with other stakeholders (e.g., EVAIR, IATA-IDX, ANSPs or other aircraft operators directly) in the scope of safety information exchange programmes in order to obtain information on challenging clearances at specific airports.
- Aircraft operators should explore how they can improve the mutual awareness between their flight crews and air traffic controllers through coordinated publications, meetings, familiarisation flights or visits to ATC facilities.

[2] *https://www.iata.org/contentassets/7a5cd514de9c4c63ba0a7ac21547477a/iata-guidance-unstable-approaches.pdf*
https://runwayexcursions.faa.gov/docs/Avoiding%20Unstable%20Approaches%20-%20Important%20Tips.pdf

2.5 Dealing safely with (late) runway changes (OPS 8)

Recommendation OPS 8: Aircraft operators should implement policies or SOPs for flight crews not to conduct takeoff or approach following any runway change until the appropriate set-up, planning, performance calculations (for multi-pilot operations this includes independent calculations and cross-checks by at least two pilots) and re-briefings are completed. When a takeoff runway change is received whilst taxiing, the above should be performed by the flight crew without rushing and when the aircraft is stationary. Runway-excursion related TEM should be addressed in the briefing every time a runway change is expected, probable or actually occurs.

Why should aircraft operators follow this recommendation?

ATCOs may try to keep the runways which are optimal for their capacity planning in use for as long as possible. Moreover, they are often not aware of the tasks involved and considerations required to safely prepare an aircraft for takeoff or landing in case of a runway or departure/approach change. These tasks include a new TEM review and briefing, new navigation and flight management computer (FMC) set-up and performance calculation. Consequently, if not previously anticipated and prepared by the flight crew, late runway changes (including intersection changes for departure or changes in the type of standard instrument departure [SID] or approach) can easily become a safety problem as they may lead to increased workload on the flight deck. The problems which might arise from this are in Table 1.

What can aircraft operators do to implement the recommendation?

In order to help flight crews dealing safely with the threat of (late) changes such as runway, intersection, departure or approach changes, an aircraft operator's duty is to provide their flight crews with adequate policies, SOPs, tools and training. The following should be considered when establishing these:

- Aircraft operators should communicate proactively to the ANSPs (e.g., via local runway safety teams and/or via their commercial contacts) that they expect their flight crews and the ANSP to always prioritise safety over efficiency. Aircraft operators should make clear to the ANSP that capacity and efficiency is not their primary concern but rather the safe conduct of their flights. They should also explain that delay vectoring to achieve better descent management or time for runway/approach changes is preferred rather than tight-and-high approach vectoring or late runway changes for capacity reasons.
- Aircraft operators should support their flight crews in anticipating runway, intersection, SID or approach changes by implementing the following via their policies, SOPs and training:

Table 1.

Takeoff	Landing
Runway excursion–related: • Errors in takeoff performance calculations (e.g., using the wrong runway, a wrong intersection or incorrect wind status); • Errors during entry of performance data into the FMC and in V-speed/N1/EPR settings (settings for specific aircraft configurations); • Line-up via the wrong intersection; and, • Procedural shortcuts (e.g., not waiting for both engines to stabilize symmetrically before applying takeoff power when being rushed). **Non-Runway excursion–related:** • Crews following the wrong taxi route; • Runway incursions; and, • Crew confusion or SID violations due to discrepancies in the stored SID in the FMC.	**Runway excursion–related:** • Rushed and unstabilised approaches; • Errors in landing performance calculations which might lead to runway excursions; • Unawareness of actual runway status and resulting stopping margin; • Unawareness of optimum runway exit, leading to taxi-off with inappropriate taxi speed; and, • Flying the wrong approach or to the wrong runway. **Non-Runway excursion–related:** • Wrong radio and navigation settings for approach; • Preparing or flying the wrong go-around route; • Discrepancies in the stored FMC data leading to crew confusion; and, • Not intercepting the cleared approach in time – this is especially critical at airports with parallel runway operations.

- Flight crews should be advised to gain awareness of the wind profile (e.g., by means of information from the operational flight plan, outside cues or pilot reports [PIREPs] from other crew) in order to prepare for a probable runway change. This can already be done during pre-flight preparation even in regard to the landing (e.g., by viewing the wind profile in the last 5,000 feet shown in the operational flight plan, if available).
- Flight crews should be provided with any relevant information regarding which runway, SID or approach they can usually expect at an airport (e.g., by means of specific airport briefing/information provided by the aircraft operator).
- Flight crews should be required to consider a possible runway, intersection, SID or approach change already in their TEM briefing for every departure and approach briefing. Actively asking ATC about any planned change of runway, SID or approach should be encouraged, if deemed useful.
- Flight crews should be required in their taxi and takeoff briefing to identify the correct runway intersection and line-up point also by visual cues, if available (e.g., wind socks, ramps, fire station). During complex taxiway arrangements, a step-by-step taxi route confirmation should be used in order to line-up the runway using the correct intersection or line-up point.

- Aircraft operators should support their flight crews in dealing safely with (late or sudden) runway, intersection or approach changes by implementing the following via their policies, SOPs and training:
  - Flight crews should refrain from accepting approach or line-up clearance for a runway until the appropriate set-up, planning, performance calculations and re-briefings are completed. Encourage flight crews to request delay vectors, or even holding or other time-generating means, if required, instead of rushing for departure or approach and landing.
  - Passenger cabin-secure readiness should also be a requirement for acceptance to line up and for final approach completion.
  - Accept departure and arrival delays, especially in the event of late changes. Support flight crews to withstand the operational pressure to go off-block or land without having prepared the runway, intersection, SID or approach change properly, just to avoid delay.
  - Consider providing flight crews with a 'Late change – checklist' covering items for the FMC and NAV set-up, performance considerations and a re-briefing (see Figure 6).
  - Require each pilot of the active flight crew to independently verify performance calculations and cross-checks.

Figure 6. **Example late change checklist**

(Late) CHANGE - CHECKLIST

DEPARTURE	APPROACH
FMS	FMS
FMS RWY/SID change?	FMS RWY/APP change?
FMS vs IAC WYPT x-check?	FMS vs IAC WYPT x-check?
SID PDG change (able?)	FMS STAR/TRANS. change (able?)
New ALT / SPD constraints	New ALT / SPD constraints
Setup	Setup
SID/RTN NAV-SET change?	APPG/A NAV-SET change?
MCP CRS SELECTORS change?	MCP CRS SELECTORS change?
RWY HDG change?	RWY HDG change?
1. STOP ALT change?	G/A ALT change?
MEOAA change? (eosid?)	MDA/DA change? (vdp/callouts?)
Performance	Performance
OPTIMYM FLAPS? (tora?)	OPTIMUM FLAPS? (reverse/a/b?)
V-SPEEDS change?	V-REF SPEED change?
T/O N1? (correct bleed setting?)	A/B CHANGE? (optimym rwy exit?)
EOSID special? (e/o holding?)	EO-G/A special? (eosid/vis.escape?)
Briefing	Briefing
New CHART X-CHECK required?	New CHART X-CHECK required?
New SID/EOSID Briefing?	New APP/G/A Briefing?
New TAXI Route?	New TAXI Route?
New Threats/Hazards?	New Threats/Hazards?

- **On ground**: During taxi, flight crews should direct their full attention to the position and movement of the aircraft at the airport. If the runway, intersection or SID change for takeoff was not anticipated by the flight crew, this might require them to do relevant work like performance calculations, new FMC and NAV set-up and re-briefing when the aircraft is stationary. Therefore, the aircraft operator's policies and SOPs should clarify that adhering to this SOP takes precedence over any time pressure like airport slots, night curfews or flight duty time restrictions in order to allow their flight crew to accomplish the necessary tasks without rushing, thereby effectively mitigating runway excursion risks.
- **In flight**: Managing and monitoring the aircraft and its flight path is of utmost importance for accident prevention. If not anticipated by the crew, a late runway or approach change (e.g., below FL100), requires a concerted set of tasks accomplished by the PF and PM. In normal operation, there is no need to accept or even request rushed approaches. Building a shared mental model, especially with regard to the approach and go-around, weather, traffic and other threats, is more important than on-time performance. Ideally, ATC should not issue runway changes to aircraft below FL100 and crews should avoid accepting them, unless required for safety reasons. If a runway change is accepted below FL100, the crew should enter a holding

pattern (if necessary) and not commence the approach until the set-up, briefings and checklists are completed.

- If their aircraft are equipped with a flight management system (FMS) capable of storing two flight plans, flight crews should consider using this feature when preparing for a departure or arrival and there is a possibility for one of two different runways to be assigned for takeoff or landing. The flight plan 'on standby' can be easily activated without a significant increase in workload.

2.6 Safety reasons for flight crews requesting runway changes (OPS 9)

Recommendation OPS 9: Aircraft operators should implement policies or SOPs for flight crews to request a more favourable runway for takeoff or landing for any reason, which may affect the safety of the flight and to advise the safety reasons to ATC.

Why should aircraft operators follow this recommendation?

ATCOs often try to keep runways which are optimal for capacity planning and/or for adherence to local noise abatement restrictions in use for as long as possible. This may lead to significant tail wind and/or crosswind operation or operation on shorter, slipperier or more performance-limited runways, despite better options being available at an airport. All of these risks can be contributing factors to runway excursion events.

In order to proactively prevent safety-critical events, there should be consensus in the industry that flight crews are allowed to request a more favourable runway for any reason which may affect the safety of their flight, even if granting such requests might lead to departure or landing delays.

Safety reasons which might lead flight crews to request another runway providing them with a greater safety margin for their departure or arrival may include, among other things:

- Wind profiles leading to reduced safety margins (e.g., a tail wind, crosswind or variable winds). It is important to understand that while the surface wind might still be within the limits, the winds at altitude are often well beyond these limitations, making it harder for flight crews to stabilise their aircraft until touchdown;
- A runway condition status estimated by the flight crew to be worse than reported (e.g., the flight crew expects the runway to be slippery wet, when only reported to be wet);
- Technical or special performance reasons (e.g., when operating with minimum equipment list [MEL] items like a locked reverser);
- Human factors reasons (e.g., fatigue when operating in a pilot's window of circadian low or a lack of proficiency);
- Approach and runway lighting considerations (e.g., at night and in marginal weather conditions);
- Engine-out or go-around climb considerations (e.g., weather, crosswind or traffic on engine-out SIDs (EOSID) or go-around);
- Crosswind limitations (e.g., in gusty winds or when using reduced crosswind limits);
- Sun-blinding at the approach minimum or during go-around and initial EO tracking; and,
- Bird concentration or significant visual flight rules (VFR) traffic.

In these cases, 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 departure or approach.

What can aircraft operators do to implement the recommendation?

An aircraft operator's duty is to provide their flight crews with adequate policies, SOPs and training, especially in safety relevant decision-making, to support them in always choosing the most appropriate runway for takeoff and landing. The following should be considered when establishing these:

- Aircraft operators should communicate actively to the ANSPs (e.g., during meetings with local runway safety teams) that they expect their flight crews and the ANSP to always prioritise safety over efficiency.
- Aircraft operators should require their flight crews to make their performance calculations also taking into account the maximum foreseeable tailwind for the takeoff or landing runway in order to gain awareness of resulting stopping margin in the event that a runway change is not possible or the weather creates variable winds (e.g., during thunderstorms).
- Aircraft operators should require their flight crews to use a conservative strategy when assessing the need for a runway change request in their TEM briefing.
- Aircraft operators should consider informing ANSPs in advance via their operations control if certain flights need to take off in the opposite direction or in a different direction than usual (e.g., due to performance limitations). This will give ATCOs and flight crews the chance to plan ahead and coordinate the best departure time or runway allocation.

(See also *OPS 6*.)

2.7 Understanding wind limitations (OPS 11)

Why should aircraft operators follow this recommendation?

Environmental threats like crosswind and tail wind components need to be safely managed by flight crews in order to prevent runway excursions. Operations in tail wind and crosswind conditions require not only specific handling techniques

Recommendation OPS 11: Aircraft operators should define company cross- and tail-wind limits which are specific to each type of aircraft operated. Moreover, specific guidance on the runway conditions and the gust components should be clarified. Aircraft operators should establish clear policies to allow their flight crew to reduce the established limits whenever deemed necessary for safety reasons in actual flight operation.

but also good knowledge of and strict adherence to the applicable cross- and tail wind limitations, depending on runway status. Aircraft manufacturers publish only an aircraft's maximum *demonstrated* crosswind capability as shown in the certification process. Using such values as actual aircraft limitations in routine operation may pose additional threats to the operation for the following reasons:

- The conditions prevailing or used during the flight tests from which such values result may be different from the conditions that flight crews may experience in daily practice (e.g., values have been achieved by test pilots).
- Only providing flight crews with recommended instead of definite crosswind or tail wind limits may put additional operational pressure on flight crews to accept and try to cope with challenging environmental conditions, despite being unable to safely do so.
- In the absence of definite company crosswind or tail wind limitations, there is an increased need for the flight operations and safety departments to conduct risk assessments of all airports in the route network and to publish limits with regard to maximum wind limits individually, irrespective of airport classification.

What can aircraft operators do to implement the recommendation?

Aircraft operators should support flight crews in safely managing threats from crosswinds and tail winds by considering at least the following when determining policies, SOPs and training regarding wind limitations:

- Aircraft operators should provide their flight crews with definite wind limitations, taking into account different runway states. These should include any gusts. These limitations should be aligned with the aircraft flight manual (AFM), flight crew training manual (FCTM) and manufacturers' guidance and include any further restrictions or guidance on wind limitations given by the manufacturers. Implementing specific drift limits for touchdown should be considered (see *OPS 21*).
- Aircraft operators should provide their flight crews with the freedom to reduce these limits whenever they deem necessary in actual flight operations (e.g., due to fatigue, proficiency issues or other safety reasons) in order to ensure safe takeoffs and landings.
- Aircraft operators should highlight in their CRM/TEM that fixed wind limits may have the potential to develop a normative goal effect, which means that flight crews think they always have to be able to take off or land up to this given wind-limit, irrespective of their actual crew performance in terms of proficiency, fatigue or other safety reasons. Training, including simulator training, should be provided to enable and encourage flight crews to consider reducing the wind limits when necessary.
- Aircraft operators should request recommendations and non-technical objections from the manufacturer when developing policy and procedures concerning wind limits in the event that no manufacturer's guidance on wind limitations is published.
- Aircraft operators should consider imposing further restrictive limitations for specific airports or situations based on the operator's risk assessments (e.g., imposing limits based on crew experience, crew composition or training). Communicating their crosswind limits for specific airports to aerodrome operators and ANSPs (e.g., via participation in local runway safety teams or via their commercial contacts) may help to achieve a common risk picture of their flight crews and ATCOs in daily operation, making it easier for both groups to deal safely with environmental threats.

2.8 Flight technique in crosswind operations (OPS 12)

Recommendation OPS 12: Aircraft operators should publish specific guidance and training for their flight crews on crosswind takeoff and landing techniques, especially in wet, slippery or contaminated runway conditions. This should include the correct touchdown and stopping techniques, which incorporate all available control and deceleration devices as well as TEM topics and methods for effective monitoring and intervention by the PM. Aircraft manufacturer's advice should be incorporated, if available.

Why should aircraft operators follow this recommendation?

Crosswinds not only contribute to runway veer-offs, on both takeoff and landing, but they can also contribute to runway overruns because the actual flare distance will be influenced by the crosswind technique used by the flight crew, thereby eventually leading to significantly reduced stopping margins. Moreover, crosswinds can also influence controllability after touchdown so that the flight crew is required to reduce their reverse thrust, which also may lead to significantly reduced stopping margins, especially in cases when performance calculations assumed uninterrupted and full use of maximum reverse thrust.

Although crosswind landings and engine-out recoveries in crosswinds on takeoff might be highly complex manoeuvres, it should be ensured that the PM is always effective in cross-checking the PF and ready to intervene with callouts or even by taking over control, if necessary, irrespective of rank and experience. This needs to be trained not only via classroom training but also via appropriate simulator intervention sessions, and appropriate documentation on the intervention SOP should be provided.

What can aircraft operators do to implement the recommendation?

Owing to differences in flight technique between fly-by-wire and conventional aircraft, only general guidance is presented. Aircraft manufacturers publish specific guidance on crosswind techniques in their respective flight crew training manuals, which take precedence. The following considerations may supplement existing recommendations:

Crosswind during takeoff:

- Initial runway alignment and smooth symmetrical thrust application result in good crosswind control capability during takeoff. For some types of aircraft, a rolling takeoff procedure may even be advised in certain crosswind or tail wind conditions to avoid engine surge. To support their flight crews, it might be helpful to inform ANSPs (e.g., via participation in local runway safety teams) about such a necessity, order to allow appropriate traffic spacing in such conditions and increase awareness and knowledge among ATCOs of specifics in aircraft operation.
- Especially in wet or slippery runway conditions, special attention should be paid to ensure the engines are spooling up symmetrically before advancing the thrust levers further for takeoff. Light forward pressure on the yoke or side stick increases nosewheel steering effectiveness. Any deviation from the centreline during thrust application should be countered with immediate smooth and positive control inputs. Aircraft operators' documentation and training should therefore also cover the use of nosewheel steering, especially with regard to whether and to what extent the use of a tiller is recommended during the initial takeoff run.
- Aircraft operators' SOPs and training should ensure that their flight crews' TEM briefing for departure covers crosswind considerations for both normal and non-normal situations. Flight crews can set their own crosswind limits for their takeoff, depending on other threats like their proficiency, experience, fatigue or runway state and can also gain awareness of the expected wind correction angle after liftoff or options for aircraft position in the event of a rejected takeoff associated with fire or smoke situations.

Crosswind during approach:

- Depending on the orographic or weather situation on approach, high crosswind situations may be accompanied by a changing wind profile from the start of the approach until landing. Aircraft operators' SOPs and training should therefore incorporate guidance for their flight crews to establish final landing configuration early on. This enables them to concentrate on their tracking, consciously perceive wind information and gain awareness of their margin for possible wind limits without being distracted by configuration changes or checklist reading.
- 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 sideslip approach or a combination of both in strong crosswind conditions. Aircraft operators' documentation should include SOPs on disconnecting the autopilot at an appropriate altitude to allow their flight crews sufficient time to establish manual control of the aircraft well before the de-crab phase and flare.

Crosswind during landing:

- Aircraft operators' SOPs and training should highlight that on wet or contaminated runways in particular, a firm touchdown is recommended to minimise the risk of aquaplaning and ensure a positive touchdown. When touching down with a residual crab angle on a dry runway, the aircraft automatically realigns with the direction of travel down the runway. This does not happen on a wet or contaminated runway.
- A residual crab angle on the runway also has some implications when reverse is selected. In the event that a lateral control problem occurs in high crosswind landings, flight crews might have to reduce reverse thrust to reverse idle and release the brakes to correct back on the centreline. This will minimise the reverse thrust side force component and provide the total tyre cornering forces for realignment with the runway centreline. Aircraft operators' documentation and training should also cover the use of nosewheel steering, especially with regard to whether and to what extent the use of a tiller is recommended during the final landing run.
- Stable approach criteria have to be met throughout the stable gate until touchdown. As crosswind situations, especially in combination with gusts and turbulence, may easily lead to lateral or vertical path deviations, it is of utmost importance that aircraft operators' SOPs and training for the PM lead to effective monitoring and intervention behaviour, irrespective of rank and experience. Their SOPs and training should also highlight that a go-around is always the favoured option instead of taking over control (e.g., by the pilot-in-command [PIC]) in order to force a landing. Their classroom and simulator intervention training should cover various situations during approach and landing requiring intervention by the PM. This should include mandatory callouts, go-arounds from various stages of the approach and

landing — even during touchdown (as long as reversers are not deployed) — as well as taking over control by the PM in order to perform a go-around, if necessary.

2.9 Technical solutions helping to prevent runway excursions (OPS 4)

Recommendation OPS 4: The aircraft operator should incorporate appropriate technical solutions to reduce runway excursion risks, where available (including ROASS, and runway veer-off awareness and alerting systems, when and if available). If technical solutions are not available, operators should implement appropriate SOPs and TEM strategies which support flight crews in effectively preventing runway excursions.

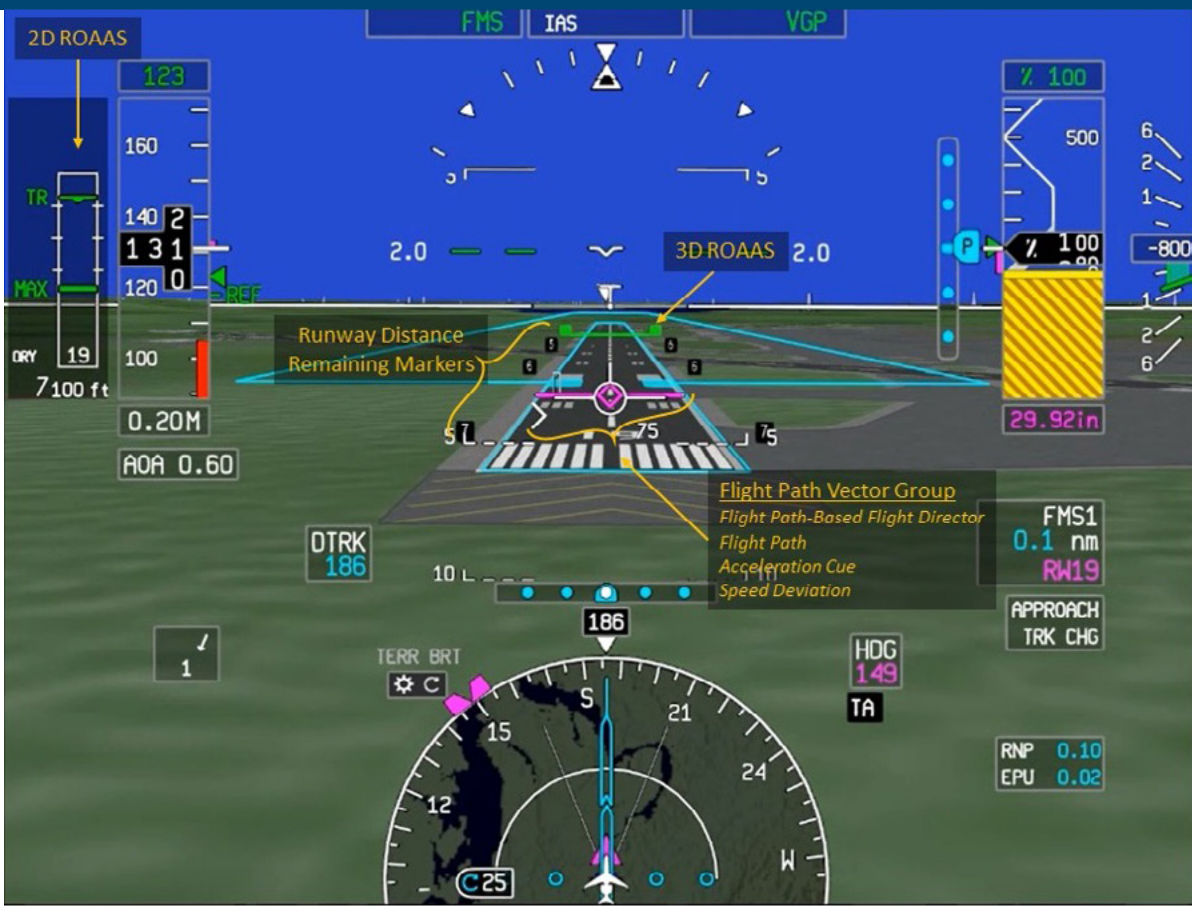
Why should aircraft operators follow this recommendation?

There are generally two types of runway excursion events: those that happen in non-normal operation (e.g., due to an aircraft malfunction like a brake or gear failure), and those that happen in normal operation, meaning with technically fully operational aircraft and no (impending) abnormal or emergency situation. Abnormal events are sometimes almost impossible for flight crews to foresee and prevent, making additional technical solutions barely effective. However, those events which occur in normal operation could be to a large extent effectively prevented by appropriate safety-relevant decision-making on the part of the flight crew. In normal operation, flight crews always have the option to make more risk-averse decisions (e.g., delay their takeoff, go around or divert).

Additional supporting systems like an airport moving map (AMM), industry solutions such as the runway awareness and advisory system (RAAS), runway overrun awareness and alerting system (ROAAS), or a head-up guidance system (HGS) can have a positive influence on flight crews' situational awareness and risk perception, thereby improving their safety-relevant decision-making (see Figure 7).

Some automated systems such as RAAS provide aural and/or visual alerts when approaching a runway, when a runway is too short or when stabilised approach criteria are being violated (e.g., too fast, too high). Some systems like ROAAS are recognised safety nets (now mandated in Europe beginning in January 2025 for new aircraft) providing an alert in flight and on the ground when there is a risk of not being able to stop within the available landing distance, thus advising to either go around when still possible, or to deploy on the ground all deceleration means. The use of a head-up

Figure 7. **Example synthetic vision system**



Courtesy of Honeywell

guidance system for all approaches may help the flight crews in their decision-making as well because most HGS provide for a 3-degree slope indication, indicate the flight path and have a guidance line for the touchdown point. Using HGS for all approaches may assist the flight crews in flying stabilised approaches. This is especially true for visual approaches when no vertical guidance (e.g., instrument landing system [ILS], precision approach path indicator [PAPI], visual approach slope indicator [VASI]) is available. Most HGS systems also have the feature showing the runway remaining after touch-down. Note also th at some synthetic visions systems (SVS) also incorporate similar energy management cues on head-down displays such as the primary flight display (PFD) (e.g., flight path vector, acceleration and speed cues, flight path reference line, runway distance remaining).

What can aircraft operators do to implement the recommendation?

As not all aircraft are already fitted with such systems in their basic configuration, aircraft operators will have to make joint business and safety cases to decide on additional investment. When considering the topic of technical solutions for the prevention of runway excursions, the following may support the decision-making process:

Aircraft operators should make themselves aware of the technical solutions currently available or which might become available in the near future. The active involvement of their pilot workforce will help to determine which technical solutions might be helpful in daily practice. Aspects to be considered are the experience and proficiency level of the pilot workforce, the number of complex and challenging airports (e.g., with short or multiple runways, steep approaches) and the amount of operational pressure on the flight crews (e.g., during high/frequent/tight schedule operations) in the route network which may suggest a benefit of additional safety investments.

- When installing additional technical solutions, their use should be clearly documented in the company procedures. The documentation should also contain any useful background information to enable flight crews to understand the limitations of such systems. In addition, provisions for appropriate pilot training for the introduction of new technical solutions will need to be addressed.
- Irrespective of the technical solution, and especially if no such technical solutions are available for a particular aircraft to aid flight crews in preventing runway excursions, the most important measure to ensure runway excursion prevention is to support the flight crews in the defensive management of threats by means of appropriate policies, SOPs and training. Therefore, operators' SOPs and briefing procedures should focus on making it easy for flight crews to gain complete awareness of threats to their operation and provide them with the power and freedom to take defensive decisions without operational pressure. Further information can be found throughout the document. An example of a threat/hazard awareness checklist to increase flight crews' awareness of threats can be found on Figure 8 (p. 73).

2.10 Flight data monitoring (FDM) and other means of detecting runway excursion risks (OPS 2, 31, 33, 35)

Recommendation OPS 2: Aircraft operators should include and monitor aircraft parameters related to potential runway excursions in their Flight Data Monitoring (FDM) programme. Whenever standardised FDM markers are provided by the industry, aircraft operators should use them with priority to ensure the effectiveness of risk mitigation and safety assurance associated with runway excursion barriers and to allow comparability on an industry level.

Recommendation OPS 31: Aircraft operators should monitor go-around policy compliance through their FDM programmes and establish go-around safety performance indicators (SPIs) for monitoring through their SMS. In addition to monitoring go-arounds, aircraft operators should also monitor discontinued approaches.

Recommendation OPS 33: Aircraft operators, for aircraft equipped with EFBs and when technically feasible, should systematically compare the EFB takeoff performance loggings with the relative FDM data to identify the takeoff runway excursion risks.

Recommendation OPS 35: Aircraft operators should consider observational procedures (e.g. Line Operations Safety Audits) to identify runway excursion safety risks precursors and best practices which cannot be captured by the traditional reporting or FDM.

Why should aircraft operators follow this recommendation?

Flight data monitoring (FDM) can be a very helpful and effective tool for enhancing safety. Especially in regard to runway

Figure 8. **Example threat/hazard awareness checklist**

THREAT / HAZARD AWARENESS TOOL

Departure Threat/Hazard Awareness

DEP AIRPORT CAT: A B C	GROUND OPS & TIME	WEATHER Δ p / LARGE SCALE WX?
FACILITIES	GND HANDLING	WIND
☐ NCF / OPS HRS RESTRICTED	☐ T/A < 50min / LATE CREW ARR	☐ VARIABLE / CALM WINDS
☐ NO ILS / RNP APP (lighting?)	☐ SECURITY SEARCH required	☐ CWC / TWC (act. limit? trend?)
☐ NO D-ATIS / NO MRC	☐ STAFF / EQPMT. missing (shift?)	☐ WIND >15kt (ops restrictions?)
☐ RCFF < 7 / PCN restricted	☐ PUSHBACK DELAY probable	☐ GUSTS (orography or roll cloud?)
☐ LOWEST T/O MINIMA > 400m	☐ RAMP / TWY CONGESTION	☐ WIND-SHEAR / LLWS (safe t/o?)
☐ AOI / CCI RELEVANT	☐ DE-/ANTI-ICING required	☐ LAND / SEA WIND EFFECTS
☐ NOTAM RELEVANT	☐ APU-LIM: ☐ N/A min (gnd air?)	☐ W.-CHANGE ALOFT (twc? wca?)
ATC / NOISE	TAXI-OUT	CLOUDS / VISIBILITY
☐ CHALLENGING / DIFFICULT ATC	☐ SHORT / LONG TAXI-ROUTE	☐ DARKNESS SR/SS: ☐ n/a
☐ HIRO / MROT / RRSM	☐ BACKTRACK required	☐ SUN POSITION (sid turns?)
☐ PARALLEL / X-ING RWYs	☐ RWY CROSSING required	☐ VISIBILITY < 5000m (trend?)
☐ SINGLE RWY / CONGEST. OPS	☐ SLIPPERY POS / APN / TWY	☐ LOW SPREAD (mist / fog?)
☐ SINGLE / REMOTE / NO ATC	☐ MARKINGS / LIGHTING / LOVIS	☐ LOW CLOUDS (<1000'? / rtn app?)
☐ HIGH TA / LATE HANDOVER	☐ HOTSPOTS / WIP / VEHICLE TFC	☐ PRECIPITATION (wiper? contam.?)
☐ NADP / COMFAIL special	☐ INBOUND TFC / T/O QUEUE	☐ CB / TCU / THERM. (t/o / sid / clb?)
ENVIRONMENT	RESTRICTIONS	ADVERSE WX
☐ TERRAIN critical (high. obstacle?)	☐ DELAY / EET ≥ PL.BT / ACSCHED.	☐ INCOMING WX (remain. time?)
☐ HIGH ELEVATION (toperf?)	☐ HOT BRAKES / SHORT T/A	☐ WX TREND DETERIORATING
☐ LOCAL WIND / WX PHENOM.	☐ DEP-NCF / RTD (outbound tfc?)	☐ TURBULENCE ON SID / CLB
☐ WATER IN VC (ponds / sea?)	☐ DEST-NCF / RTA / DBC-DLY	☐ THUNDERSTORM (vc? embd?)
☐ BIRDS (flocks? migration time?)	☐ FDT / RT MARGIN < 2h	☐ ICING / HAIL / +SN / VA / SA
☐ VFR / DRONE TFC (controlled?)	☐ SNOW REMOVAL probable	☐ OAT <10° (cold wx ops?)
☐ PEAK / HUB TFC (wk/time of day?)	☐ H.O.T LIMITED (precipitat. trend?)	☐ OAT >30° / TEMP INVERSION
VL L M H	VL L M H	VL L M H

TOPERF / SID & HUMAN FACTORS RWY / SID / TOPERF CHANGE?		EO / EMERGENCY RETURN
RWY: INT: ☐ N/A	MATOW: ☐ MTOW	EOSID
☐ INTSCT. T/O (line-up / tora / view?)	☐ HEAVY / LOW GW (rotation / eo?)	☐ EOSID - SID DEV. PRIOR 400'
☐ RWY - TORA<2500m (oppos. tdz?)	☐ A/C - SYS. MALF. / MEL-OPS	☐ EOSID - COMPLEX (wca? navs?)
☐ RWY - WET / DAMP (realist.ba?)	☐ A/C - DIFFERENCES (1FMC? CBN?)	☐ EOSID - EARLY TURN (mrva?)
☐ RWY - SLIPPERY / CONTAMIN.	☐ BLEED / FLAP SETTING special	☐ EOSID - OPPOSITE TO SID
☐ RWY - SLOPE (uneven rwy? birds?)	☐ NADP 1 OR SPEC. / Δ V1/R > 4 kts	☐ EOSID - LATE ACCEL. (msa? turn?)
☐ RWY - WIDTH <40m (cwc? load?)	☐ STOP MARGIN < 200m (line-up?)	☐ EOSID - WX / TFC / TERR critical
☐ W/S TOPERF REQ. (wx / rwy / gw?)	☐ CWC / TWC LIM: ☐ 25 / 0	☐ EOSID - EO ON SID CRITICAL
SID:	RNAV: B P RNP: 1 2	EMERGENCY RETURN
☐ RTE 2 REQ (rwy / sid / sfx change?)	☐ SID-COMPLEX (early a/p? exp. wca?)	☐ RTN - RWY ≠ DEP RWY
☐ NO IMM. T/O (atc-unable info!)	☐ SID-EARLY TURN (sun pos.? mrva?)	☐ RTN - NO VIS RTN / OPP. LDG
☐ T/O NEAR MINTOF (t/o queue?)	☐ SID-EARLY LVL-OFF (early a/p?)	☐ RTN - OVERWT (max t/d v/s? ldr?)
☐ UNEVEN RWY / NO RCLL	☐ SID-PDG > 3,3% (able? nadp?)	☐ RTN - LDA < 2500m
☐ SPACING / WAKES / LLTURB.	☐ SID-OPPOS. TFC (early a/p / v/s?)	☐ RTN - WX / TFC / TERR critical
☐ BIRDS / VFR / DRONE (360°view?)	☐ SID-WX critical (cb, tcu ts, w/s, ice?)	☐ RTN - NO ILS/RNP (exp. app?)
☐ F/D OFF / R. DATA / M.THR.	☐ WX-RADAR / WIPER REQ.	☐ RTN - APP: EO G/A special
HUMAN FACTORS		T/O ALTERNATE ☐ N/A
☐ FATIGUE / FITNESS (crew?)	☐ NEAR LIMIT OPERATION	☐ ALT - NO ILS/RNP (exp. app?)
☐ AWAKE > 10h (time in wocl?)	☐ UNFAMILIAR AIRPORT / VARIANT	☐ ALT - LDA < 2500m
☐ EMOTIONAL / STRESSED	☐ WORK-ERROR(S) > 2	☐ ALT - WX / TFC / TERR critical
☐ PERCEIVED TIME PRESSURE	☐ WORK ATMOSPHERE	☐ ALT - NOTAM relevant
☐ PROFICIENCY (self or crew)	☐ SPORTY / SLOPPY ATTITUDE	☐ DIV - RTE WX / ICE / TERR (mfa?)
☐ COMPLACENCY / ROUTINE	☐ LOW ROLE / TYPE EXPERIENCE	☐ DIV - RTE TFC / VFR / SUA
☐ IDLE TIME / DISTRACTION	☐ TRAINING / CHECK / OBS FLT	☐ DIV - EET > 30min
VL L	M H	VL L M H

Arrival Threat/Hazard Awareness

DEST. AIRPORT CAT: A B C	ARRIVAL & TIME WIND-PROFILE?	WEATHER Δ p / LARGE SCALE WX?
FACILITIES	DESCENT	WIND
☐ NCF / OPS HRS RESTRICTED	☐ DES - EARLY / STEP-WISE	☐ VARIABLE / CALM WINDS
☐ NO ILS/RNP APP (lighting?)	☐ DES - TFC (below / slow / opposite?)	☐ CWC / TWC (act. limit? trend?)
☐ NO D-ATIS / NO MRC	☐ DES - TWC / WIND CHANGE	☐ WIND >15kt (ops restrictions?)
☐ RCFF < 7 / PCN restricted	☐ DES - TURB / WX (cat / cb/tcu / ice)	☐ GUSTS (orography or roll cloud?)
☐ LOWEST APP MINIMA > 550m	☐ CABIN NOT READY YET	☐ WIND-SHEAR / LLWS (safe ldg?)
☐ AOI / CCI RELEVANT	☐ TRANSITION / HOLDING	☐ LAND / SEA WIND EFFECTS
☐ NOTAM RELEVANT	☐ SNOW REMOVAL probable	☐ W.-CHANGE ALOFT (twc? Wca?)
ATC / NOISE	TAXI-IN	CLOUDS / VISIBILITY
☐ CHALLENGING / DIFFICULT ATC	☐ SHORT / LONG TAXI-ROUTE	☐ DARKNESS SR/SS: ☐ n/a
☐ HIRO / MROT / RRSM	☐ BACKTRACK required	☐ SUN POSITION (app / g/a / turns?)
☐ PARALLEL / X-ING RWYs	☐ RWY CROSSING required	☐ VISIBILITY < 5000m (trend?)
☐ SINGLE RWY / CONGEST. OPS	☐ SLIPPERY HST / TWY / APN/POS	☐ LOW SPREAD (mist / fog?)
☐ SINGLE / REMOTE / NO ATC	☐ MARKINGS / LIGHTING / LOVIS	☐ LOW CLOUDS (<1000'?)
☐ HIGH TL / LATE HANDOVER	☐ HOTSPOTS / WIP / VEHICLE TFC	☐ PRECIPITATION (wiper? contam.?)
☐ NADP / COMFAIL special	☐ SMALL / CROWDED APRON	☐ CB / TCU / THERM (des / app / ga?)
ENVIRONMENT	RESTRICTIONS	ADVERSE WX
☐ TERRAIN critical (high. obstacle?)	☐ DELAY / POS OCCUP / ACSCHED.	☐ INCOMING WX (remain. time?)
☐ HIGH ELEVATION:	☐ NEXT T/A < 50min / AC CHANGE	☐ WX TREND DETERIORATING
☐ LOCAL WIND / WX PHENOM.	☐ DEST-NCF / RTA / DBC-DLY	☐ TURBULENCE IN DES / APP
☐ WATER IN VC (ponds / sea?)	☐ DEP-NCF / RTD (outbound tfc?)	☐ THUNDERSTORM (vc? embd?)
☐ BIRDS (flocks? migration time?)	☐ FDT / RT MARGIN < 2h	☐ ICING / HAIL / +SN / VA / SA
☐ VFR / DRONE TFC (controlled?)	☐ APU-LIM: ☐ N/A min (gnd air?)	☐ OAT <10° (cold wx ops?)
☐ PEAK / HUB TFC (wk/time of day?)	☐ PROCEED. AFT / IMM / CUSTOM	☐ OAT >30° / TEMP INVERSION
VL L M H	VL L M H	VL L M H

LANDPERF / APP / LDG & HUMAN FACTORS RWY / APP CHANGE?		GO-AROUND / DIVERSION
RWY: W.ADD: ☐ +5	MALW: ☐ MLW OLD: ☐ < 20000m	GO-AROUND
☐ DISPLACED THRHLD (lda? vis.ill.?)	☐ HEAVY / LOW GW (config timing?)	☐ G/A - EARLY TURN (wx / sun?)
☐ RWY - LDA < 2500m (tpl? mgn?)	☐ A/C - SYS. MALF. / MEL-OPS	☐ G/A - EARLY LVL OFF (tfc?)
☐ RWY - WET / DAMP (realist.ba?)	☐ A/C - DIFFERENCES (1FMC? CBN?)	☐ G/A - WX / TFC / TERR critical
☐ RWY - SLIPPERY / CONTAMIN.	☐ BLEED / FLAP SETTING special	☐ G/A - PROFICIENCY / RAW DATA
☐ RWY - SLOPE (uneven rwy? flare?)	☐ REVERSE / MAX MANUAL BRK	☐ G/A - GRADIENT > 2,5%
☐ RWY - WIDTH < 40m (cwc?)	☐ STOP MARGIN < 200m (tpl req.?)	☐ G/A - SPEC. EO G/A REQ.
☐ RWY - FL15 LDG DIST. LIMITED	☐ CWC / TWC LIM: ☐ 33 / 15	☐ BALKED LDG SPECIAL (eosid?)
APP:	RNAV: B P RNP: 2 1 .3	DIVERSION
☐ RTE 2 REQ (rwy / app / sfx change?)	☐ NO FULL LIGHTING / BLACKHOLE	☐ EXTRA FUEL < 10 MIN
☐ FMC ≠ IAC / NO FMC DATA	☐ PAPI ≠ G/P / IMPAIR. or NO PAPI	☐ NO 2. G/A OPTION
☐ G/P INTCPT: < > 9NM FINAL	☐ BARO ≠ RA (rising / falling terrain?)	☐ NO OPTION TO STAY
☐ G/P > 3° (v/s >1000?, early conf.?)	☐ VISUAL ILLUSION / SUN-BLIND.	☐ DIV RTE - WX / ICE / TERR (mfa?)
☐ TWC ON FINAL (wind-change?)	☐ TURBULENCE < 1000' / WAKES	☐ DIV RTE - TFC / VFR / SUA
☐ IAN / L/V-NAV (g/s-off? gps? rnp?)	☐ TDZ LOW DENS. / C/O CONGEST.	☐ DIV RTE - NO DIRECTS AVAIL.
☐ F/D OFF / RAW DATA (wca? p/p?)	☐ WX-RADAR / WIPER REQ.	☐ DIV RTE - EET < 15 MIN
HUMAN FACTORS		DEST. ALTERNATE(S)
☐ FATIGUE / FITNESS (crew?)	☐ NEAR LIMIT OPERATION	☐ D. ALT - NO ILS/RNP (exp. app?)
☐ AWAKE > 10h (time in wocl?)	☐ UNFAMILIAR DEST / D.ALT	☐ D. ALT - LDA < 2500m
☐ EMOTIONAL / STRESSED	☐ WORK-ERROR(S) > 2	☐ D. ALT - WX / TFC / TERR critical
☐ PERCEIVED TIME PRESSURE	☐ WORK ATMOSPHERE	☐ D. ALT - NOTAM relevant
☐ PROFICIENCY (self or crew)	☐ SPORTY / SLOPPY ATTITUDE	☐ D. ALT - MIN. FUEL ON APP
☐ COMPLACENCY / ROUTINE	☐ LOW ROLE / TYPE EXPERIENCE	☐ D. ALT - NCF / PARKING limited
☐ IDLE TIME / DISTRACTION	☐ TRAINING / CHECK / OBS FLT	☐ D. ALT - OPS / HOTAC limited
VL L	M H	VL L M H

excursion prevention, aircraft operators can use it to track relevant safety performance indicators (SPI) such as go-around rates from unstable or discontinued approaches or precursors leading to unstable approaches. Setting runway excursion–related SPIs for both takeoff and landing helps operator's management to ensure safety performance.

Another option providing useful data to assess an aircraft operator's runway excursion risk is the use of line operations safety audits (LOSA). As with FDM, data collection depends heavily on flight crews' trust in and buy-in to the tool. To help them introduce and carry out a LOSA project, aircraft operators may choose to use International Civil Aviation Organization (ICAO) Doc 9803 as guidance material.

What can aircraft operators do to implement the recommendation?

The main objective when using FDM, LOSA or other tools in the context of runway excursion prevention is to gain awareness of precursors for runway excursion risks in aircraft operators' operations. The focus of attention should therefore be on finding safety issues associated with takeoff, approach and landing operations. The following proposals may help to set up the tools properly:

- Aircraft operators should target a 100 percent coverage of flights by their FDM programme. Precursors for runway excursion events might be relatively rare and missing some may easily distort the understanding of an aircraft operator's actual risk.
- Aircraft operators should consider using industry best practices on FDM (e.g., as described by the EOFDM forum, a voluntary and independent safety initiative). Aircraft operators thus have the option to obtain precursors which have already been subject to a risk-based analysis, receive additional information on their implementation, or compare their operation with that of others in order to share lessons learned and mutually improve their operations. The EOFDM's work[3] provides a list of precursor factors for several types of runway excursion accidents and several flight data measurements. In total, the report lists 34 precursors for runway excursion and more for other high-risk events which can be used to develop safety performance indicators.
- Aircraft operators should be transparent and promulgate among their pilot workforce relevant material on FDM, LOSA or other data collection tools. They should explain and make clear which precursors and methods aircraft operators use and what their targets are. This enhances trust in aircraft operators and their FDM. In a healthy and positive safety culture, FDM can then even serve as an individual feedback tool for their flight crews. Insights gained can be used for simulator and classroom CRM/TEM/accident prevention training as well.

2.11 The use of data-link systems (OPS 5)

Recommendation OPS 5: If technically feasible, aircraft operators should equip their aircraft fleet with data-link systems (e.g. ACARS) enabling them to digitally obtain the latest weather information (e.g. D-ATIS or METAR). The use of this technical means has to be supported by adequate SOPs enabling all pilots on the flight deck to familiarise themselves with the latest weather conditions without impeding aircraft and flight path monitoring.

Why should aircraft operators follow this recommendation?

Preventing runway excursions is primarily a matter of flight crews' safety-relevant decision-making. This, in turn, requires that all pilots on the flight deck possess a shared and realistic mental picture of the actual and expected environmental conditions for takeoff and/or landing, such as weather and runway conditions. In order to enable flight crews to receive this information on time for use in their briefings and resulting decision-making (e.g., in the event of an (impending) runway change), it should be made as easy as possible for them to obtain and understand such information. Voice only methods (e.g., VHF-ATIS or meteorological information for aircraft in flight [VOLMET]) can be time-consuming and error-prone due to impaired VHF-reception and differences in handwriting quality. This method should therefore only be used as a backup solution. Using digital means (e.g., via ACARS or the Internet) simplifies the process of information gathering and ensures that the information documented is not outdated, misunderstood, wrong or illegible.

Moreover, the use of data-link systems allows the flight crew to obtain current weather information without a single pilot losing situational awareness. It also allows for an improved follow-up in a rapidly changing weather environment, thereby again enhancing the flight crew's awareness and decision-making. By requiring all flight crew members on a flight deck (e.g., on enlarged flights) to familiarise themselves with the actual and expected conditions, their potential to detect and correct unsafe situations (e.g., failing to go around if required) can be increased as additional flight crew members (e.g., supernumerary or enlarged crew) are able to monitor the active flight crew's decision-making with regard to the actual conditions and can also intervene, if required.

What can aircraft operators do to implement the recommendation?

- If not already implemented, aircraft operators should consider a business case for the investment in digital means for weather information reception on the flight deck. This should be underpinned by a realistic safety case or risk assessment taking into account aspects such as route profile, age structure of the pilot workforce, etc.
- When installing data-link systems, their use 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 by the active flight crew (e.g., during the final approach phase).
- In general, procedures or policies may require the active flight crew to share safety-relevant information with observers or additional crew members on the flight deck, provided they are judged as qualified, and invite them to support and monitor the active flight crew's decision-making. Digital means may facilitate that flight crews use this option.
- In the event that aircraft operators consider not providing the technical means to print the digitally obtained weather/airport information, specific procedures should be implemented ensuring continuous monitoring of the aircraft and its flight path by at least one pilot, while the other familiarises him/herself with the information, especially if the presentation format of the weather information on the display unit makes it hard to read or understand

[3] *https://www.easa.europa.eu/domains/safety-management/safety-promotion/european-operators-flight-data-monitoring-eofdm-forum#group-easa-downloads*

(e.g., ATIS information being meshed or covering several pages on an FMS control display unit [CDU]).

2.12 Check of current conditions versus planned conditions (OPS 10)

Recommendation OPS 10: Aircraft operators should implement policies or SOPs requiring flight crews to confirm prior to commencing the takeoff or landing phase that the actual conditions (weather and aircraft configuration) are better or at least correspond to the values used for performance calculations. When conditions are predicted to approach operational limitations, flight crews should be required to identify the limiting parameters and incorporate this information into their TEM briefing.

Why should aircraft operators follow this recommendation?

Runway excursions, and runway overruns in particular, are often caused by more than one factor.[4] These include, among others, tail winds, long landings, high touchdown speeds, late or inappropriate use of reverse thrust or speed brakes, and reduced runway friction or contamination. For the prevention of runway excursions, it is therefore of utmost importance that the environmental conditions and aircraft configuration used during the takeoff and landing performance calculations are the same as the actual conditions during takeoff and landing. Otherwise, the actual takeoff or landing might be conducted with significantly reduced or even no safety margins (e.g., if there is a tail wind instead of no wind or a head wind, runway status is worse than calculated, autobrake is used instead of maximum manual braking or idle reverse is used instead of maximum reverse thrust as assumed in the performance calculations).

What can aircraft operators do to implement the recommendation?

- Make sure (e.g., by means of appropriate training and easy-to-use and understandable documentation) that flight crews and operations staff (when doing performance calculations) know exactly what they are calculating with regard to the safety factors used and assumptions made by the performance calculation program or tables.
- Allow flight crews and operations staff to make conservative calculations based on their knowledge and experience (e.g. incorporating changes in wind, temperature, QNH, runway status), even if this might lead to operational restrictions (e.g., diversions, reaching flight duty time limits). At the actual time of departure or arrival, weather conditions can be different from those at the time of dispatch or even from those at the time of the approach briefing. Although it might be commercially sound to use exact environmental parameters at the time of calculation, this might, in reality, lead to takeoffs or landings with reduced or no safety margins. The following list may be used as a guideline to cope with this threat. Implementation will make it easier for flight crews to assess their actual safety margin shortly before takeoff and landing, thereby avoiding time consuming re-calculations, unnecessary go-arounds or diversions:
  - In headwind situations, flight crews may be allowed to do performance calculations based on zero wind.
  - In calm or variable wind situations, flight crews may use a minimum of 5 kts tailwind for their calculations.
  - If a variable range of wind direction is given (e.g., 330/5 300V360), flight crews should use the most negative value for the given runway direction.
  - In tail wind situations, flight crews may consider effects causing increasing tail winds (e.g., by incoming weather or land/sea wind effects).
  - For every takeoff, flight crews may search for cues (e.g., operational flight plan wind information at SID waypoints, trails of smoke or clouds, PIREPs) to estimate the wind aloft to get an idea of possible wind shifts (e.g., towards tail wind) affecting the takeoff path or their EOSID.
  - Gross weight and temperature values used for calculation should reflect actual or realistic numbers at the time of break-release or touchdown (e.g., actual takeoff weight [TOW] higher than load-sheet value due to short taxi-out or higher landing weight [LW] due to shortcuts on approach).
- During their TEM briefing, flight crews should pay special attention to significant changes or trends in wind direction and/or runway surface conditions (e.g., due to incoming or deteriorating weather situations). They should try to anticipate relevant changes as early and as comprehensively as possible. Options which might help to gain the necessary awareness may include, in addition to ATIS or METAR information, to ask for PIREPs or ATC information, or even to use certain smartphone weather apps providing more detailed weather information (if approved by the operator). If it is foreseeable that operational limits will be reached (e.g., wind or runway contamination limits) they should discuss alternatives for their departure or landing as well as defining their acceptable limits, if different from published limits. (see *OPS 11*).
- When approaching the runway, either before takeoff or before landing, flight crews should mention any updates to their takeoff or approach briefing focussing on possible differences to the planned versus actual conditions.
- Ensure through SOPs and training that flight crews always verify (and possibly call out) before line-up that they have

[4] *https://www.iata.org/en/publications/safety-report/*

identified and are using the correct runway, the correct intersection and the correct line-up procedure, as used in their takeoff performance calculations (see recommendation *OPS 27*, *OPS 28*)

- Ensure through SOPs and training that flight crews are aware of the wind and runway conditions given with the takeoff or landing clearance and that they check that these conditions are consistent with those used for the performance calculations.
- Flight crews should check the latest weather information before their in-flight landing distance assessment is conducted. If sufficient time remains and cockpit duties allow it, crews should 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 ATCO.

3 Special considerations for the departure phase

3.1 Takeoff performance and the use of EFB (OPS 13, 34)

Recommendation OPS 13 a: Aircraft operators should ensure their policies or SOPs require flight crews to perform independent performance calculations. This should also include independent cross-checks of the load and trim sheet and the actual TORA/TODA from the AIS (e.g. if reduced by NOTAM) with TORA/TODA used to calculate the takeoff performance. This independent calculation should also be applied following a runway change.

Recommendation OPS 13 b: Aircraft operators should ensure their policies or SOPs include flight crew gross error checks and crew cross-checks prior to any data input and prior to executing any data input in the FMS.

Recommendation OPS 34: Aircraft operators, for aircraft equipped with EFBs and when technically feasible, should visualise on the EFB the FULL RWY with its planned T/O RWY holding position to increase the situational awareness of the crew for the intended T/O position.

Why should aircraft operators follow this recommendation?

Many runway safety events stem from erroneous or inadequate takeoff performance calculations and errors made during transfer and input of data into the FMC. Such errors are all preventable if flight crews are supported by customised SOPs, appropriate training and a safety-focussed work environment. Load and trim sheet as well as takeoff performance calculations are usually performed just before departure when the flight crew is exposed to various distractions. Therefore, the effective prevention of errors in takeoff performance calculations very much depends on the ability and freedom of the flight crew to safely manage external threats like time pressure, distraction or fatigue.

A first step in preventing runway excursion is a critical check of the load and trim sheet data, irrespective of whether it is provided by a third party or generated in the cockpit by the flight crew. Only if a check is carried out to ensure that the load and trim sheet values match reality in terms of passenger/baggage/cargo weights, seating and load distribution, including a check of the pre-defined values such as dry operating weight/index and takeoff, trip and taxi fuel, and all resulting values are within the allowed limits, can this data serve as the basis for takeoff performance calculations. This check should always be done independently by all active crew members on the flight deck. For the following calculation of takeoff performance either using electronic means such as EFB solutions or paper versions, it is again highly recommended that all active crew members on the flight deck verify their own performance calculations independently and then cross-check them with each other, even if this is time-consuming.

EFB solutions incorporating navigational charts and applications for flight planning such as takeoff and landing performance calculation programs are already widely used in the industry as they not only save costs but also can simplify processes for flight crews (e.g., by making performance calculations easier and faster). However, their use requires up-to-date and accurate databases as well as an adequate user interface. If threats like runway shortenings, intersection closures, etc., are not incorporated in time into the database used for performance calculations, the probability of the flight crew failing to detect such errors is high, especially as current NOTAM format and presentation in aviation in combination with fatigue, time pressure or complacency may lead to flight crews sometimes not reading or checking NOTAM information properly.

In order to make it as easy as possible for flight crews to prevent input errors (e.g., environmental or aircraft configuration data) and as easy as possible to understand the calculation results in terms of the safety margin provided for their takeoff, the EFB solution should incorporate nudges[5] (that may be reminders such as pop-ups and triggers) and means of visualisation. Visualisation in particular is a great tool to enable flight crews to easily build a correct risk picture for their takeoff in terms of runway excursion prevention. Being aware of the additional stop margin resulting from their calculation and being able to easily cross-check that the takeoff position and line-up procedure used for the calculation matches the one expected or used is key for flight crews' safety-relevant decision-making (e.g., deciding on a re-calculation or accepting or rejecting line-up clearances). If technically feasible, visualisation of this information should therefore combine results of performance calculations and airport layouts.

Regardless of whether an FMC or non-FMC equipped aircraft is used, the subsequent process of setting the takeoff speeds (V_1, Vr, V2) and respective engine parameters (e.g., N1, Derate, Flex/AssTemp) or bug setting needs to be done in a coordinated manner to reduce input error and allow effective cross-checking. Again, these steps require an environment

[5] Nudges are interventions that preserve the freedom of choice but that nonetheless influence people's decisions.

which allows safe management of distraction and time pressure by the flight crew. There should be consensus in the industry that safety considerations always take precedence over time or efficiency considerations. As correct takeoff performance calculations are one of the top priorities for runway excursion prevention, flight crews should be encouraged by aircraft operators to accept a departure delay, if required, in order to always perform these tasks properly.

What can aircraft operators do to implement the recommendation?

To enable flawless and time-saving processes with load sheet and takeoff performance calculations in daily operation, aircraft operators should put in place customised SOPs supporting their flight crews in effectively preventing or detecting errors during calculation, cross-checks and data-input.

Below is some guidance on how this could be achieved:

- In general aircraft operators should:
  - Provide special guidance to cabin crew and handling agents stipulating that they should not disturb flight crews while they are performing load sheet performance calculations, data insertions or briefings. This could be achieved by incorporating relevant guidance or regulations into service contracts with ground handling companies and by making this matter a topic in CRM training for cabin crews. Aircraft operators' flight crew CRM/TEM training should provide guidance on how to mitigate the risks posed by distraction and time pressure before departure.
  - Consider promoting safety reporting on frequent errors by flight crews with regard to performance calculations and use line check or LOSA data to detect flaws in the input design of EFB or EFB SOP. They should also use their pilot workforce actively to find the best SOP set for their EFB solution in their operation.
  - Ensure that EFB back-end processes are able to cover safety-relevant changes to performance databases in order to provide safe and valid data to the front-end at all times.
  - Use company NOTAMs or equivalent means to inform flight crews and dispatch staff about short-term changes to runway and performance data.
  - Use 'highlighting or marking' of relevant NOTAM information in flight preparation tools to make it easy for their flight crews to detect safety-relevant changes to runway data and ultimately detect errors in performance databases more easily.
  - Provide flight crews with sufficient time for pre-flight preparation in order to enable them to read and analyse NOTAM information properly (consider establishing a delay code for extended flight preparation).
- Load and trim sheet

  When designing the SOPs for preparing and cross-checking the load and trim sheet, aircraft operators should consider the following:
  - All information which flight crews relay or use for preparing the load and trim sheet (e.g., trip or load sheet data information such as takeoff, trip and taxi fuel, dry operating weight/dry operating index [DOW/DOI]) should be cross-checked by the pilot who did not fill in the form in question.
  - Before the aircraft doors are closed, ground handling staff, or equivalent, should be required to report to the flight crew the final number of passengers who went through the departure gate (or final load data in the case of cargo flights) and the final load distribution as per information provided by the gate and loading personnel (by intentionally not referring to the latest edition of the load sheet) in order to make it possible to detect any load sheet errors before departure. Timing of ground processes and setting of turn-around times should incorporate margin for error detection and clarification in case of deviations.
  - At least the final version of the load and trim sheet should be checked independently by all active crew members on the flight deck.
- Performance calculation

  When designing the SOPs for calculating safe takeoff performance, aircraft operators should consider the following:
  - Irrespective of the source of the performance data provided to aircraft operators, aircraft operators should ensure that these data are correct and safe for use. This can be ensured by effective auditing processes. However, if aircraft operators are not using active flight crews which have direct experience with the use of the audited EFB solution as auditors, it is important to incorporate feedback and experience from line operation into the audit checklists and briefing for the auditors. Otherwise, they will not be able to detect flaws in the use nor ensure the unambiguity, clarity, validity and preciseness of the performance data and EFB processes.
  - To allow flight crews to consider different scenarios already in the takeoff/TEM briefing, the aircraft operators' SOP should require the flight crew to calculate preliminary takeoff performance prior to the briefing using the most realistic and expectable values in terms of gross weight and environmental conditions. In some cases, it might also be necessary to consider assessing the landing performance in case of immediate return or to consider a takeoff alternate. SOPs should require that takeoff performance calculations be performed prior to the briefing with most realistic and expectable values.
  - In case of enlarged crews, aircraft operators should consider how to incorporate the additional flight crew members in the process of takeoff performance

calculation, too, in order to ensure a best use of all resources available.

- Aircraft operators should ensure that the performance calculation, its cross-check and the following steps for preparing the aircraft for departure can be accomplished by the flight crew without rushing. Therefore, timing of processes, definition of departure delay and turn-around times should incorporate sufficient margin to mitigate time pressure and hurry-up syndrome, especially in cases when the final load and trim sheet is received only shortly before scheduled/planned departure times.
- The SOP for cross-checking the results of the calculation should allow flight crews to carry out the cross-check intuitively and easily. It should require flight crews to check not only the results but also the input data, such as aircraft tail sign, runway, intersection and environmental and aircraft configuration data. The scan pattern should be prescribed and follow an intuitively recognizable reason.
- However, the use of cross-checks alone is often a weak risk control measure to ensure that flight crews correctly insert all relevant environmental and aircraft configuration data. The influences of fatigue, lack of proficiency, good SOPs or training, distraction or time pressure may lead to inadequate cross-checks by flight crew. Little nudges or triggers throughout the input process are helpful and effective in ensuring that flight crews make the correct inputs right away (e.g., a pop-up if wet runway was selected together with a low outside air temperature [OAT], but without engine anti-ice). The following list of nudges/triggers might be useful:
  - Pop-up for engine anti-ice;
  - Pop-up for wind limits;
  - Pop-up for weight limits;
  - Pop-up for information on remaining stop margin; and,
  - Pop-up for minimum equipment list (MEL) items and considerations.
- In cases where a class 1 EFB is used for the performance calculation, each crew member should be provided with an EFB to ensure proper independence of calculation and cross-check.
- When using paper-based takeoff performance calculations, special considerations should be given to readability of tables and charts and the need for interpolation.
- In any case, the actual TORA/TODA, especially if being altered by NOTAM, should be checked against the value used in the takeoff performance program or table/chart individually and independently by each flight crew member. If it is not technically feasible to combine the results of takeoff performance calculations and airport/runway layout in one visualisation, at least the EFB solution should make it possible to visualise the available stop margin in relation to the TORA. The SOP should then require the flight crew to visually confirm the runway and takeoff position used during the calculation on the airport layout chart and estimate the available stop margin.

■ Data entry into the FMC

In order to ensure an error-proof SOP for transferring or entering data into the FMC, aircraft operators should consider the following:

- This data insertion is usually done just before departure when the flight crew is exposed to various distractions. Aircraft operators should encourage flight crews to be assertive in not allowing themselves to be distracted or feel time pressure when accomplishing this task.
- The load and trim sheet data and the takeoff performance data can be entered via a single process or a split process. In any case, the data input should be performed by the pilots together in a concerted manner to avoid errors like entering the zero fuel weight (ZFW) as takeoff weight/gross weight (TOW/GW), or entering the wrong flaps setting or takeoff parameters. Therefore, it is suggested that one pilot states the value to be entered first before the other pilot enters it into the FMC. This allows for initial gross error checks for plausibility (e.g., the ZFW, the TOW and fuel loaded). Before executing the entry, the pilot who gave the value should again confirm that it has been entered correctly in terms of value and box/position in the FMC before giving the execution command or signalling agreement for execution.
- SOPs which allow one pilot to enter final weight or performance values without supervision and cross-checking should be avoided, even if single cross-checks are used and the values to be entered are given by the other pilot in any later step. Mutual entry and cross-checks are more effective and thereby safer. They may even save more time, especially in cases when errors are made and new calculations/entries have to be made.
- In any case, each pilot should also be required to critically check the 'reasonableness' of the combination of flaps settings, takeoff reference speeds and thrust settings by using their experience and intuition. 'Doubt is a fact' — if any pilot feels unsure about the values, they should be recalculated, even if it takes time. Aircraft operators should give special consideration to this when operating mixed fleets and should consider providing their flight crews with guidelines or standard values to make checking the reasonableness of takeoff data simpler.
- Wherever technically possible, cross-checks should be performed between independently calculated values

by the FMC and performance calculation tools, EFB or paper-based (e.g., characteristic minimum manoeuvring speeds such as minimum clean speed).

- As a backup, aircraft operators should consider investing in safety by using technology that automatically checks the data entered into the FMC for consistency between the takeoff parameters (e.g., takeoff securing (TOS) by Airbus).

Additional material is provided in the IATA "FMS Data Entry Prevention Errors – Best Practices".[6]

- (Late) changes

The same precautions and thoroughness in safe takeoff performance calculations as mentioned above are valid in the event of any (late) changes. The following list provides an overview of situations requiring the flight crew to recalculate and reinsert takeoff performance data:

- Runway and/or intersection changes;
- Obvious environmental changes (e.g., wind, temperature, runway status);
- Unplanned selection of performance-influencing systems (e.g.. anti-ice);
- Prolonged idle time (e.g., in case of waiting time for de-icing, slot, etc.);
- Reasonable doubt of either pilot regarding the correctness of the data;
- Load and trim sheet changes; and,
- Aircraft defects (e.g., MEL items).

- Additional considerations

Flight crew training is based on monitoring and responding to the attainment of takeoff reference speeds. However, crews have few options of detecting reduced or degraded takeoff acceleration until approaching the end of the runway. Technology providers have an important role to play in developing systems that provide alerts to the flight crew when the actual acceleration is too low in order to enable a safe takeoff (e.g., 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 relating to takeoff performance calculations should be fed back to the crews to raise their awareness and share the lessons learned (e.g., study insights about increased passenger weights, study insights on erroneous takeoff performance calculations or incident/accident examples).

(See *OPS 8*.)

3.2 The rejected takeoff decision process (OPS 14)

Recommendation OPS 14: Aircraft operators should publish SOPs and guidance which incorporate runway excursion mitigation associated with rejected takeoff decision-making and rejected takeoff manoeuvres. Appropriate training should be provided.

Why should aircraft operators follow this recommendation?

Flight crews can prevent runway excursions during takeoff through proper takeoff decision-making. This includes the decision-making involved in both initiating and rejecting a takeoff.

Runway veer-offs typically occur at low speed owing to a flight crew's mismanagement of the beginning of the takeoff roll (e.g., if flight crews mishandle the transfer of directional control from tiller to rudder or between either pilots or if they do not ensure symmetrical engine spool up before applying takeoff power.) This frequently happens during rolling takeoffs, when flight crews are under actual or perceived time pressure for reasons including actual time constraints such as night curfews or slots or from perceived time pressure resulting from ATC's spacing.

Runway overruns are often the result of attempts to reject a takeoff above V1 (the maximum speed at which the pilot must take the first action to reject a takeoff [e.g., apply brakes, reduce thrust, deploy speed brakes]), errors in takeoff performance calculations or aircraft being aerodynamically unable to fly owing to loading errors or ice build-up. To guarantee safe aircraft stopping within the calculated accelerate-stop distance during a rejected takeoff (RTO), it is of utmost importance that the takeoff performance calculations are made using a conservative strategy or that they at least reflect the actual conditions during takeoff in terms of aircraft weight and runway status. Therefore, not only are the takeoff speeds key elements for a safe takeoff, but also the flight crew's awareness of additional threats influencing the available stop margin in case of an abort, too. Factors like fatigue, lack of proficiency or possible distractions during the takeoff run (e.g., by radio/telephony [R/T] traffic, emotional stress owing to time pressure, pressure from ATC or a negative work atmosphere in the cockpit) may lead to incorrect recognition of failures or delayed abort initiation.

The most important speed range for failure management and takeoff abort decision-making is the high-speed segment of the takeoff run, which is typically between 80 kts and 100 kts (depending on the operator and aircraft type) and just before V1. When rejecting a takeoff near V1, a pilot's reaction time to

[6] *https://www.iata.org/contentassets/b6eb2adc248c484192101edd1ed36015/fms-data-entry-error-prevention-ed-1-2015.pdf*

initiate the stop is critical. Considering a typical medium to large turbofan aircraft's V1 is to150 kts, this would mean using up the available stopping margin by a minimum of 80 m per second of delayed abort initiation. Given the fact that today many takeoffs are calculated as balanced field takeoffs, giving no or only around 150 m additional stopping margin, and that factors like rudder deposit in the opposite touchdown zone (especially on short runways) may significantly reduce runway friction, policies or SOPs requiring conservative takeoff performance calculations are needed.

What can aircraft operators do to implement the recommendation?

Ensuring that takeoffs and (RTOs) do not lead to runway excursions is also a matter of aircraft operators' policies and SOPs on takeoff performance calculations and takeoff and reject initiation, as well as the associated pilot training. The following should be considered when establishing such SOPs and training practices:

- Aircraft operators should provide SOPs requiring that ground staff and flight crews cross-check actual passenger, baggage or cargo loading arrangements before the closure of aircraft doors in order to guarantee that the aircraft is loaded as stated on the load and trim sheet used by the flight crews for takeoff performance calculation.
- Aircraft operators should provide SOPs for flight crews defining under which conditions rolling takeoffs are allowed. This should include considerations regarding runway status, crosswinds and requirements for handover of control, as well as differences in engine spool up behaviour (e.g., after an engine change). These SOPs should require flight crews to use a conservative strategy when considering rolling takeoffs and should encourage them not to accept any time pressure (e.g., from schedule considerations or ATC).
- Aircraft operators should provide clear and robust SOPs for RTOs, in particular based on clearly documented criteria for mandatory RTO up to 80/100 knots and from there to V1. The SOPs should specify who may call out a stop decision in both ranges and explicitly require that an RTO attempt above V1 should only be made when it is impossible to get airborne (e.g., owing to significant centre of gravity loading issues). RTO actions for the high-speed case should be unequivocally stated, including maximum braking unless there is a very clear indication that this would cause other control problems. If using the terms "unsafe or unable to fly" as a criterion to reject a takeoff, aircraft operators should consider differentiating or explaining them further in their procedures and training, as this may include influences such as aircraft icing, load issues, errors in takeoff performance calculations, large negative speed trends due to tire failures or go-around traffic above. This will help to reduce psychological barriers which might be stopping flight crews from rejecting a takeoff because of possible self-induced mistakes, thus helping to avoid unsafe takeoff attempts.
- Although the PIC has the final responsibility for the safety of a flight, that does not necessarily mean that the PIC has to make the decision to abort a takeoff. Both pilots on a flight deck have to be trained in safe RTO decision-making and RTO execution to ensure proper reaction in the event of obvious or subtle incapacitation or a delayed failure recognition by either pilot at any stage during the takeoff run, including the high-speed portion up to V1. For the sake of runway excursion prevention, it is more important that the allocation of the reject decision, the reject execution and the task sharing between the PF and PM guarantee safe takeoff decisions and a minimum failure recognition and reaction time on every flight.
- The RTO manoeuvre is a mandatory item in the operator's proficiency check (OPC). Flight crews are therefore trained in 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. Therefore, aircraft operators should consider the following concerning flight crew's RTO training:
  - It is strongly recommended that recurrent training and checking, as well as initial pilot training (e.g., operator conversion courses, type ratings and 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 tyre burst close to V1, nose gear vibrations, engine stalls, bird strikes at high speed, wind shear or uneven aircraft acceleration, opening of side window, instrument failures, or flight control issues. These exercises can also be used to provide training in dealing safely with startle effects.[7] In all cases, both pilot roles (PIC or second-in-command [SIC]) should be equally trained in deciding on and making RTOs at various stages throughout the takeoff, including different scenarios (e.g., low speed/high weight, high speed/high weight, wind shear induced, incapacitation at low speed and at high speed) in order to guarantee safe takeoff decisions.
  - The training goal should be to make flight crews confident in taking the right decision (to reject or not to reject) in every case. Therefore, specific training on the topic of RTO with regard to TEM awareness and briefings is also recommended. Items like the additional stop margin available on takeoff, taking into account specific hazards affecting an RTO (e.g., strong crosswinds, low speed aborts in high thrust/low weight situations), should be part of every flight crew's departure briefing. This should not only be documented but also taught both in classroom CRM/TEM training and simulator training.
  - Irrespective of to whom the decision and task of an RTO is allocated, the essential supporting and monitoring task of the other pilot should be emphasised. This

[7] *https://www.easa.europa.eu/sites/default/files/dfu/EASA_Research_Startle_Effect_Managements_Final_Report.pdf*

includes monitoring of thrust parameters, monitoring the speed trend, performing timely standard callouts, detecting and identifying abnormal conditions, monitoring the use of all braking and stopping devices, and verifying maximum braking is applied continuously unless control issues dictate otherwise.

3.3 Correct line-up for departure (OPS 27, 28)

Recommendation OPS 27: Aircraft operators should implement policy, technical solutions or SOPs which confirm that the aircraft is lining up on the planned runway, its centreline and via the correct intersection.

Recommendation OPS 28: Aircraft operators should publish SOPs and guidance for their flight crew not to accept line-up, backtrack or takeoff clearances until pre-takeoff preparation (including cabin secure), procedures and checklists are completed to the appropriate point which permits the accomplishment of the associated manoeuvre without delay and until they have reported "ready for departure" to ATC. Aircraft operators should publish an explicit SOP for "rolling takeoffs".

Why should aircraft operators follow this recommendation?

Unclear markings/lighting of runways and taxiways are hazards which may be encountered in operation, and flight crews can make unintended errors. Either combination of imperfections can result in misjudgement or failures, leading flight crews to take the wrong runway or intersection, lining up using a different line-up technique than calculated, thereby losing or reducing their additional stopping margin, or lining up for takeoff despite not actually being ready for departure, both procedure-wise and mentally.

Maintaining good situational awareness is one of the most important ways that flight crews can operate safely and prevent incidents and accidents. In order to enable flight crews to do so, they need good policies, SOPs or technical solutions as well as good training. Otherwise, common threats like schedule or ATC pressure, impaired teamwork on the flight deck due to steep cockpit authority gradients, mismanaged distractions, confusing or ambiguous airport/chart layouts or missing runway markings/lighting/signing may contribute to runway excursion events in their operation.

What can aircraft operators do to implement the recommendation?

In order to make it easy for their flight crews to avoid line-up errors, aircraft operators have the following options:

- **Technical solutions:** Modern EFB solutions provide airport moving map (AMM) functions allowing flight crews to monitor their position at all times. This increases situational awareness and might help prevent errors during taxi and takeoff briefings, and reduces the risk of taking wrong runway intersections for takeoff. Other tools like the runway advisory and awareness system or takeoff securing function (e.g., TOS by Airbus) may provide additional support for flight crews by using aural advisories on runway entry or FMS messages by issue alerts if discrepancies on runway usage are detected. The proper use of such tools should be documented and trained, including hints on how to use marking or highlighting of taxi routes, hotspots or intersections.
- **Airport briefings:** Complex airports and layouts leading to long and complicated taxi routes and several options when selecting different runway intersections may pose more runway excursion risks to flight operation than airports with only one runway and no intersections available. By providing comprehensive airport briefings, aircraft operators can ensure that all their flight crews, including those which have not visited a specific airport before, are sufficiently aware of any hotspots or runway excursion risks like taking the wrong runway or intersection. Good airline processes to implement or maintain airport briefings include the proactive involvement of the aircraft operator's and airport's safety departments, which may add valuable information on frequent errors or occurrences reported by flight crews, ATCOs or airport staff.
- **SOPs:** A first step in preventing runway excursion is the pre-flight procedure. Therefore, the following should be included as a minimum for runway excursion prevention in aircraft operators' SOP:
  - During their TEM briefing, the flight crew should positively identify the aircraft's parking position in relation to the expected runway and/or intersection for takeoff, considering possible late runway or intersection changes in order to avoid any taxi and line-up errors. Especially in cases of very short taxi times, flight crews should consider planning their off-block, start of taxi as well as the taxi speed to allow all necessary duties and reports (e.g., cabin secure) to be accomplished without rushing.
  - Flight crews should be required to consider the line-up procedure available or expected by ATC for the respective runway or intersection and to include this in their takeoff performance calculations. Especially in cases when ATC expects, and the flight crew accepts, a rolling takeoff, this may significantly use up the stopping margin and therefore needs to be considered in the

calculations. In any case, flight crews must be aware of which line-up technique is incorporated in their take-off performance calculations (e.g., 90 or 180 degrees, rolling via the taxi line, backtrack).

- As there are different interpretations by manufacturers, flight crews and ATCOs of what a rolling takeoff means, aircraft operators should clarify this in their documentation and with the ANSPs of their route network, if required (e.g., via participation in local runway safety teams or via their commercial contacts). As a rolling takeoff may not always leave sufficient time for the flight crew on the runway to identify correct line-up, this type of line-up requires special considerations by the flight crew. These could be to identify the correct line-up position, to review the RTO case or to gain additional awareness of the actual runway/wind status or the weather/traffic in the departure sector. Additional threats like night or low visibility operation, no or bad taxi or runway markings/lighting may contribute to errors in correct line-up and should be dealt with in the TEM briefing and considered before accepting or requesting a rolling takeoff. ANSPs should also be advised that time for engine spool up may vary according to aircraft type. Therefore, they should bear in mind in their sequence planning that departing aircraft might need up to 30 seconds on the runway before starting to move. This time span may be even longer in winter operation if engine checks or run-ups are needed.
- The SOP for a rolling takeoff should therefore ensure that flight crews accept or plan such a manoeuvre only if they are certain that they do not need additional time on the runway (e.g., for weather radar scanning, adjusting sun visors, waiting for winds to be in limits or reviewing RTO or engine out procedures). This SOP should help to prevent any active pilot in the flight crew from being mentally distracted when starting the takeoff run and any procedural task in the pre-take-off procedure from being missed (e.g. switching on a traffic-alert and collision avoidance system (TCAS), weather radar, receiving cabin secure report)
- Make sure via the SOP that flight crews report 'ready for departure' to ATC only if all required tasks, including the 'cabin secure', if applicable, have been accomplished. Frequently used alternatives like 'ready upon reaching' should be explicitly avoided. Consider making 'cabin secure' an item for flight crew's pre-takeoff checklist or allow reading of the pre-takeoff checklist only after the cabin secure information has been received. Allow and encourage flight crews to reject any request or instruction by ATC for an immediate line-up or takeoff if not all pilots on the flight deck are actually ready for such a procedure, both mentally and procedure-wise.
- To prevent or detect any line-up errors, aircraft operators' SOP should ensure that flight crews have to positively identify and call out the runway and intersection before line-up (e.g., the PF or PM calls out: 'RWY 08R, Intersection A4 – identified'). Consider adding a trigger or nudge for flight crews to mentally recheck the takeoff performance calculation by the latest at this stage as well, if this was not already required during review of the takeoff briefing when approaching the takeoff runway.
- Aircraft operators' SOP should also give guidance for flight crews on how to deal with cases requiring long backtracks (e.g., half the runway or more). Such situations are connected with time pressure due to incoming traffic and can pose additional threats to their flights (e.g., forgetting procedural items due to distraction or even missing turn-around taxi guidance at turning bays or runway beginnings). They can even contribute directly to runway excursions.

■ **Training:** Preventing runway excursions is not only a matter of pilots' technical competencies in dealing with threats like crosswinds, slippery runways or technical failures but also, more often, it is a matter of pilots' non-technical competencies like safety-relevant decision-making, situational awareness and clear communication within the flight crew and ATC. Therefore, flight crew training and checking with regard to runway excursion prevention should focus on the following elements:

- Encouraging and rewarding assertive behaviour (e.g., being reluctant to accept challenging ATC clearances like immediate takeoffs and being persistent when having doubts — for example, when unsure about the wind information in a takeoff clearance or when unsure about the status of cabin preparation — "doubt is a fact".)
- Training in anticipative behaviour and thorough TEM briefings
- Training in different line-up techniques

(See *OPS 4*, *OPS 8*.)

4 Special considerations for the arrival phase

4.1 Safe descent, approach, landing and go-around policies (OPS 7)

Recommendation OPS 7: Aircraft operators should implement policies for safe descent and approach planning, stabilised approach, safe landing and go-around and should ensure that these are implemented in their training. Aircraft operators should define which elements of these policies have to be included and highlighted during the approach briefings by flight crews.

Why should aircraft operators follow this recommendation?

According to the 2018 Boeing statistical summary, 60 percent of all fatal accidents between 2008 and 2017 happened in the arrival phase of a flight, which includes the descent, initial approach, final approach and landing. Even the numbers of the 2019 EASA annual safety review show that runway excursions are still one of the two top key risk areas in the risk portfolio for commercial air transport (CAT) airlines, air taxi and non-commercial complex businesses based on accident data from 2014–2018. Although the first version of our action plan for the prevention of runway excursions (EAPPRE 2013) might have already had some positive impact, as shown by the analysis by the NLR (Figure 9), we still need to make further efforts to improve our industry's safety performance, especially with regard to the prevention of runway excursions.

In terms of runway excursion prevention on landing, all measures taken by aircraft operators, ANSPs, airport operators, manufacturers and regulators should have one primary and common goal which is to enable flight crews/unmanned aircraft to land on a runway safely and leave it safely via a taxiway. The role of an aircraft operator is to provide its flight crews (including remote operators) with appropriate policies, SOPs and training to achieve this common goal. Its policies, SOPs and training determine to a very large extent whether flight crews can effectively prevent runway excursions on landing.

What can aircraft operators do to implement the recommendation?

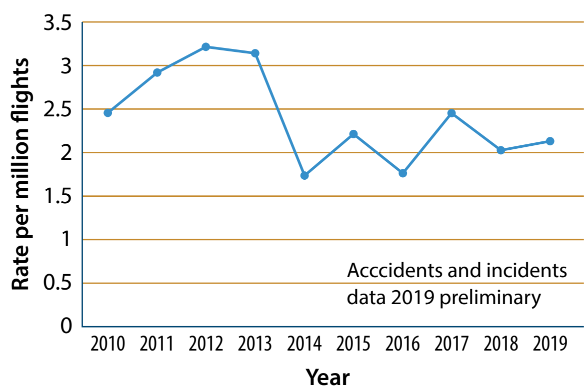
Aircraft operators' policies, SOPs and training should provide a holistic and practical set of guidelines and actions for their flight crews which make it as easy as possible for them to create the required safety margins throughout the arrival flight phase, including the sub-flight phases of descent, approach, landing and go-around. The following should be considered when establishing such SOPs and training practices:

General

- First of all, the aircraft operator's safety policy and thereby their SOPs should aim to eliminate any operational pressure on flight crews which could encourage them to rush briefings or performance calculations, land from an unstable approach or take unnecessary risks in challenging weather conditions.

  This is especially important for the prevention of runway excursions in normal operation (i.e., with technically fully operational aircraft[8] and no (impending) non-normal or emergency situation). In normal operation, flight crews always have the option to handle all relevant threats to their flights (e.g., weather, traffic, fatigue, distractions) in a defensive/conservative (i.e., risk-averse) manner, and can thus reduce complexity in given situations and work as intended by their SOPs. In non-normal operation, this freedom may be limited, depending on the nature of the non-normal or emergency situation (e.g., during landing with known or unknown tyre failure, a fire or medical emergency on board).
- For flight crews, the work of ensuring a safe descent, approach, landing and taxi-in begins during their pre-flight preparation when considering and anticipating the threats to be managed during the arrival phase of their flight. Aircraft operators' policy for determining the block fuel should therefore require that flight crews consider specific threats (which increase the risks of runway excursions) in their fuel decision before departure in order to ensure that they always have sufficient options to take safe decisions during arrival and approach (e.g., delay the approach, hold or go-around). At least the following common threats which increase the risk of runway excursions should be considered in the fuel decision:

Figure 9. **Worldwide RE occurrence rate, commercial flights**



Source: NLR

[8] This includes flights with dispatched MEL items

- Destination and/or destination alternate have performance-limiting runways in combination with unfavourable weather conditions;
- Destination and/or destination alternate have no 3D (e.g,. ILS, required navigation performance [RNP] and localizer performance with vertical guidance [LPV]) approach) available, which increases the risk of unstable approaches;
- Destination and/or destination alternate have ATC environments which tend to lead to 'hot and high' vectoring or tight spacing, increasing the risk of unstable approaches and landings; and,
- Destination and/or destination alternate operate with tailwind components TWC or may impose (late) runway changes.

- The aircraft operator's policy for determining the landing performance limits during dispatch should require dispatch personnel and flight crews to use conservative values (e.g., for wind components and runway conditions according to the latest weather report and forecast available) in order to dispatch a flight legally, even if this results in reducing the allowed traffic load, flight diversions or cancellations. (See also *4.2* for a detailed explanation.)

Safe arrival planning and descent

- Aircraft operators should require their flight crews to prepare each approach and landing thoroughly, even if they fly into an airport frequently or within short intervals. The structure of this preparation, especially in terms of a thorough TEM analysis, should be the same for every approach and landing attempt, although the time needed for this may vary, depending on the structure used for the approach briefing (e.g., when using the T-P-C briefing method[9]). Therefore, flight crews should be required to start the approach preparation sufficiently early during cruise flight in order to be finished with the approach briefing before the top of descent, considering also early or step descents or increased ATC communication when nearing the destination. On flights with longer cruise segments, the flight crews should be required to agree on an approximate time when the approach briefing will start so that every flight crew member can manage his/her other duties and tasks in time to be fully attentive for the approach briefing. In order to guarantee thoroughness of approach preparation and reduce distractions to aircraft operation and monitoring, especially on short flights, the flight crew might need to do parts of the approach planning and briefing already on the ground or incorporate the TEM analysis for the approach into their pre-flight preparation. Aircraft operators' processes should incorporate such circumstances (e.g., by adapting reporting times or allowing the flight crews to make or accept departure delays). In any case, aircraft operators' policies or SOPs should provide an option for their flight crews to enter holdings or take delay vectoring if not able to complete the approach preparation before starting an approach (e.g., in case of last-minute runway changes or on flights with only little or even no cruise time).

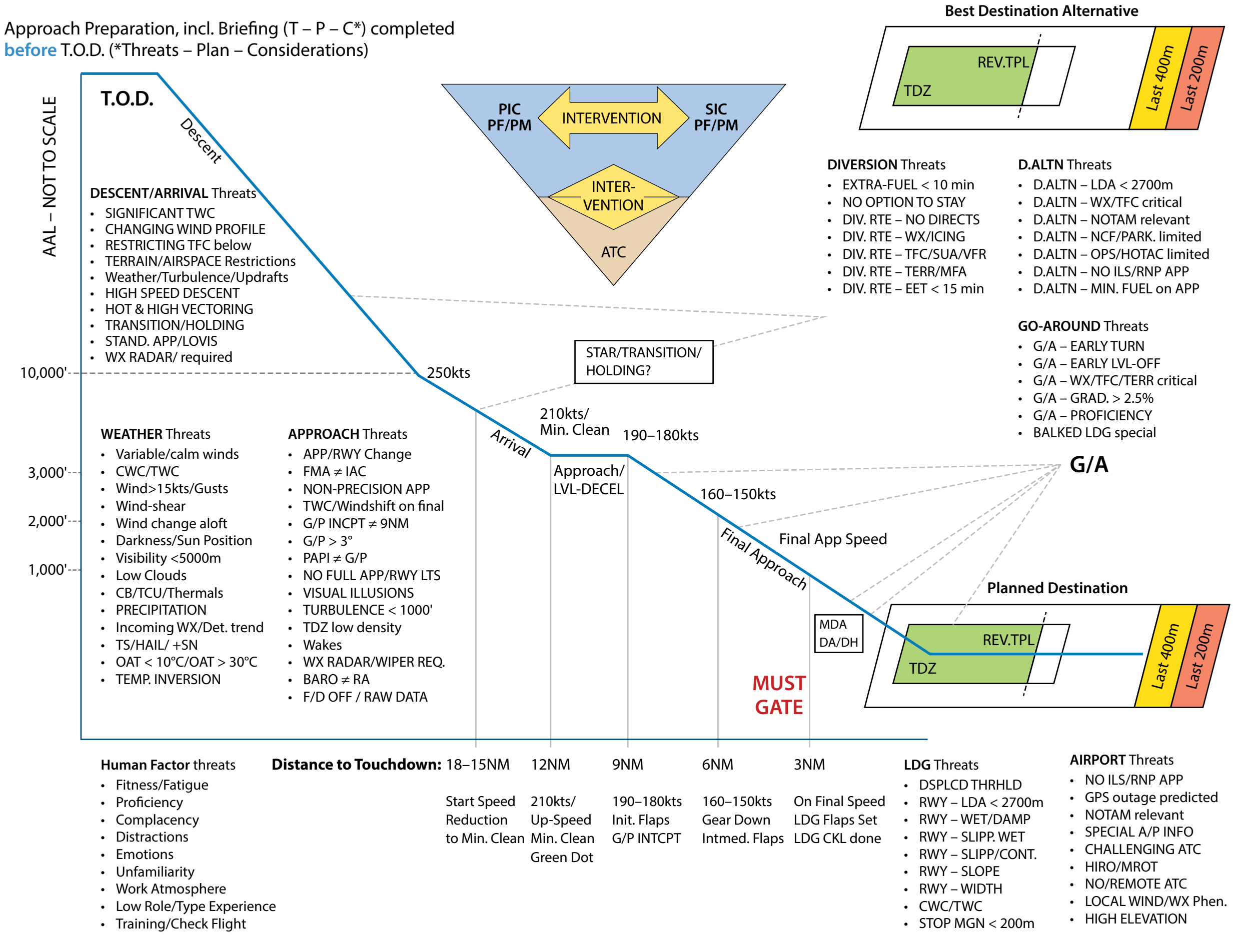
  In order to effectively mitigate any runway excursion risks, the approach preparation and briefing should cover at least the following:

  - A thorough threat analysis for the descent, approach, landing, go-around and taxi-in, including the aircraft status, human factors, weather and traffic situation, approach and runway/taxiway specifics (see more details and a list of common threats leading to runway excursions in Figure 10 (p. 86). Flight crew briefing should focus especially on revising conditions that would require a go-around and/or rejected landing instead of focussing mainly on approach, landing and rollout procedure.
  - A joint landing performance assessment by the flight crew based on individual (by each flight crew member) and conservative calculations, especially with regard to runway status and wind components, in order to determine the additional stop margin and go-around performance available (see *OPS 15*).
  - A joint flight crew decision on when to start the descent or plan for alternatives, if different from the FMC top of descent (e.g., due to traffic or weather).
  - A joint flight crew decision on the runway, the touchdown point limit and configuration used for landing (See *OPS 21*).
  - A joint flight crew decision on the type of approach and methods used (e.g., use of automatic modes or from which point in the approach manual flight is planned).
  - A joint flight crew decision on whether and to what extent operational limits such as crosswind limits have to be reduced (e.g., due to fatigue, proficiency and experience) and whether and which additional gates have to be set throughout the approach (e.g., for approach continuation regarding wind limits, runway friction values, visibility). This should include canned decisions in marginal conditions.
  - A review of those items which have to be rehearsed in the approach briefing (e.g., the go-around procedure to achieve psychological priming for go-around or the point of first configuration change, gear selection or final configuration).

- Aircraft operators should require flight crews to perform the descent with a conservative strategy, especially with regard to energy management and thus distance needed for losing altitude. Although air traffic controllers have a basic understanding of aircraft performance, they might not be aware of aircraft–type-specific or environmental threats which can reduce the descent and speed reduction

[9] Threat – Plans – Considerations: A threat-based briefing method see: *https://flightsafety.org/asw-article/rethinking-the-briefing/*

Figure 10. Example safe arrival planning (based on medium to large turbofan aircraft (e.g., A320/B737), adaptions for different aircraft type may be needed



capability of an aircraft (e.g., ineffective speed brakes, a high aircraft gross weight and changing wind profiles or thermals). Therefore, flight crews should be encouraged by policy or SOPs to reject any challenging clearances (e.g., by using the wording 'unable', and to request or plan more mileage for descent instead. Aircraft operators' SOPs should specify that high speed flying (>250 kts) below 10,000 ft, early gear extension or interception of the approach glide path from above in order to match an ATC given or planned descent path should not be used, if not required for non-normal or emergency procedures.

- Although continuous descent operations (CDO) and low drag approaches (LDA) may be favourable for economic, ecological and noise reasons, their safe conduct requires many optimal conditions to be present, which might not always be the case in reality. Influences of changing wind profiles during descent, intermediate level-offs due to airspace structure, aircraft-related factors or human factors on the flight deck, like fatigue or proficiency, may unnecessarily increase complexity for a flight crew during CDO or LDA. In order to always ensure safe approach path management by flight crews, aircraft operators may wish to consider establishing further mileage/altitude/speed gates as a baseline for a safe approach path to support flight crews in achieving stable approaches, thereby preventing runway excursion events. The following values for medium to large aircraft (e.g., A320/B737) may serve as an example (adaptions for different operations or aircraft type may be needed) (see *OPS 18*):

- Last 18–15 nm from touchdown: speed reduction (depending on aircraft gross weight, wind, aircraft's speed-reduction capabilities) from 250 kts to 210 kts or minimum clean speed should be initiated;
- Last 12 NM from touchdown: the aircraft should be flying at a maximum speed of 210 kts. A '12 miles to touchdown' callout by the PM could be a helpful tool to raise awareness for the PF, especially on approaches without a direct indication of mileage to the runway. Flight crews should be required to plan a level segment for further speed reduction and start of initial configuration.
- Last 9 NM from touchdown/3,000 ft above aerodrome level (AAL): the aircraft should be flying at a maximum speed of 180 kts and an initial flap setting;
- Last 6 NM from touchdown/2,000 ft AAL: the gear should be lowered and an intermediate flap setting selected; airspeed should be around 150 kts;
- Last 3 NM from touchdown/1,000 ft AAL: final flaps should have been selected, landing checklist completed and the aircraft should have reached final approach speed.

Safe approach, landing and go-around

- Aircraft operators should require flight crews to always choose the type of approach which best suits the individual crew composition in terms of the fitness, abilities and proficiency of the PF and the fitness and assertiveness of the PM. This may lead to choosing a complex manual flown circling or visual approach by a very fit and proficient crew which collaborates well or opting for a standard ILS approach using automation if the flight crew's team performance may be degraded. It is important that aircraft operators' policy for approach selection does not only cover external factors like weather or facilities, but also human factors in the cockpit, like fatigue, proficiency or work atmosphere. Furthermore, aircraft operators should consider classifying 2D non-precision approaches as non-normal manoeuvres and require special considerations for such approaches (e.g., early final configuration, autopilot coupling (see also *OPS 17*).
- Aircraft operators should require flight crews to actively observe and highlight significant wind changes below 10,000 ft until touchdown in order to anticipate possible influences on the descent path and speed reduction capability (e.g., strong tail winds on base leg or final or positive wind on final which requires an earlier configuration).
- Aircraft operators should require flight crews to take into account the weather and traffic situation along the missed-approach routing in their decision to start or continue an approach. Such policies or SOP should ensure that flight crews always retain an option for a safe go-around, even if this means not starting an approach or discontinuing it early. Low-level turns below minimum radar vectoring altitude (MRVA), even in visual conditions, often considered as an alternative option (e.g., to avoid nearby thunderstorms or traffic) should be avoided.

Safe taxi-in

Aircraft operators should require flight crews to include the taxi-in briefing in the approach briefing, considering especially the surface condition and maximum speeds when leaving the runway (e.g., when using slippery wet high-speed turnoff). Special considerations should be given to a change of control, if necessary, during landing rollout (see also *OPS 26*).

Flight crew training

Aircraft operators should consider critically reviewing their training philosophy on a recurrent basis to ensure that it clearly prioritises safety in all its components and incorporates the items mentioned above. An aircraft operators' flight crew training personnel, such as line training pilots, type rating instructors or examiners, should be required to always act as role models for line pilots, focussing on a defensive and conservative approach to flight operations and thoroughness in SOP adherence. Moreover, their role and status may inhibit cockpit team members from behaving assertively. In general, flight crew training should incorporate intervention training, both in the simulator and classroom CRM/TEM training, using scenarios which require flight crews to practice assertive behaviour, both in the cockpit within the flight deck team and outside the cockpit (e.g., towards ATC or towards their operations control) in order to always guarantee safe team decision-making by flight crews in daily practice.

4.2 Landing performance — correct assessment and implications for aircraft stopping (OPS 15, 23, 24, 30)

Recommendation OPS 15: Aircraft operators should develop SOPs which include an assessment, possibly prior to the top of descent, of landing performance based on the latest and best-available weather information. This calculation should not be performed using dispatch weather information. Flight crews should be informed of the type of landing distance data available (factored or unfactored) and of which correlating safety factors are used. When possible, the crew should complete descent, approach, landing planning, set-up and briefings prior to the top-of-descent.

Recommendation OPS 23: Aircraft operators should publish SOPs for their flight crews when runway conditions are uncertain or actual or anticipated slippery wet, slippery or contaminated, to fully use all deceleration means, including speed brakes, wheel braking and reverse thrust irrespective of noise-related restrictions, until a safe stop is assured, unless this causes controllability issues.

Recommendation OPS 24: Aircraft operators should publish SOPs and guidance and provide training highlighting the importance of active monitoring, including monitoring of the activation of the stopping devices on landing, and effective intervention during landing associated with pilot monitoring duties and performance. Appropriate training should be provided.

Recommendation OPS 30: Aircraft operators should, when determining their TEM strategies and SOPs, identify runways with a remaining safety margin of less than 400 m/1,200 ft after application of all required safety factors as safety critical.

Why should aircraft operators follow this recommendation?

Aircraft operators' main duty in the aviation system is to ensure safe transport. Ensuring Guaranteeing safe flights is not only a goal, but an obligation for everybody working in this high-risk environment to always put safety in front of other objectives like on-time performance, traffic capacity, fuel efficiency, noise or passenger comfort. This is especially important with regard to the industry's approach to landing performance, its calculation and its assessment. There should be consensus in our industry that a defensive and conservative (i.e., risk-averse) approach to landing performance should be promoted and applied even if this leads to an increase in go-arounds, diversions or flight cancellations.

In practice, even the landing performance on a relatively long runway (e.g., >2,500 m/>8200 ft) can easily be limited for a flight crew by the aircraft type, the actual status of the runway and other factors like wind, touchdown point, aircraft system degradations or human performance variations. Although dispatch and some operational landing distance values include certain safety factors to absorb some deviations, the dispatch as well as any operational landing distance or actual runway available may not be adequate when more than one deviation from the reference conditions come together. The shorter the runway, the more safety-critical these deviation effects may become.

The following data show 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 Quick Reference Handbook (QRH) data on the bar chart below is based on: 1,500-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 in Figure 11 and Figure 12 represents the dispatch requirement that is 1.92 times the dry runway capability of the aeroplane. Each downward bar demonstrates the cumulative effect of the operational variation listed. In overrun incidents, there are usually a number of factors that contribute to using up the margin available, especially if the runway has poorer wet runway friction capability.

Figure 11 shows 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 occur, the dispatch landing distance or actual runway available may not be adequate.

For example, wheel braking may be reduced on the wet runway because of questionable runway conditions caused by rubber build-up, polishing, or puddling due to heavy rain or poor drainage. The following charts show 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.

Figure 12 shows that if there is a possibility of a runway being wet, one can very quickly use up the entire margin in the dispatch wet runway calculation. Therefore, dispatchers and flight crews should perform dispatch landing performance calculations using conservative values (e.g., for wind components and runway conditions, according to the latest weather report and forecast available) in order to dispatch a flight legally, even if this results in reducing the allowed traffic load for a flight.

Time of landing/in-flight assessment of landing performance

Taking a conservative approach to flight operations becomes an even more valuable tool for preventing runway excursions when determining, while still in flight, the landing performance. Flight crews need to be able to know what weather conditions they can accept for the landing to be performed

Figure 11. **Wet landing distance – BA: Good**

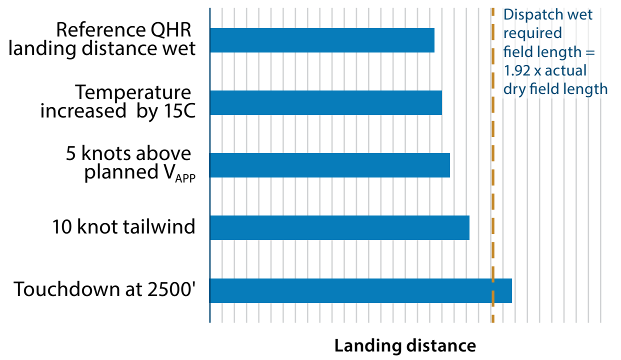
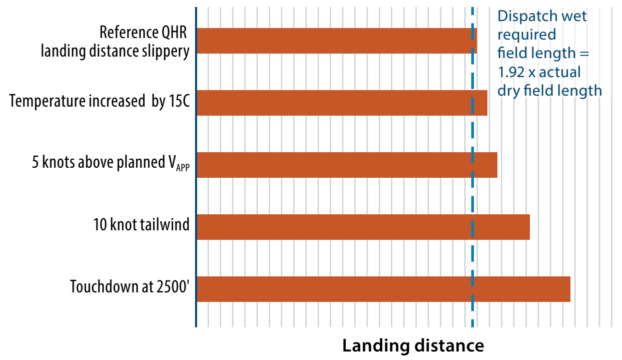


Figure 12. **Wet landing distance – BA: Medium**



safely, so that they can decide in time on possible holdings, diversions or go-arounds.

With the introduction of the ICAO Global Reporting Format (GRF), an at-time-of-landing assessment of landing performance is becoming mandatory or already is mandatory (e.g., in the European region; see EC965/2012 CAT.OP.MPA 303 303 — check of landing distance at time of arrival). There are good reasons to comply with this requirement for every approach and landing:

- The dispatch calculation usually yields results in weight limitation only and not the runway length required, making it hard for flight crews to estimate the additional stop margin available in relation to runway length available. Landing an aircraft without knowing its exact performance and safety margin reduces situational awareness of flight crews and may lead to inappropriate flight crew decision-making. (Providing results in runway length required for dispatch calculations would have 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.)
- Weather forecasts are not describing precisely the actual weather at the time of arrival. Especially in demanding weather situations, flight crews need an assessment of landing performance (e.g., during the approach preparation, which is based on latest weather information and not on that used for dispatch calculations) in order to make informed decisions such as which landing flap configuration or which type of braking (e.g., autobrake or manual braking) or which amount of reverse thrust is needed to land safely.
- Some approaches require special go-around considerations in case of engine failure upon initiation or during the go-around (e.g., due to bird strike), and landing performance does not only cover landing distance assessment but also go-around climb gradient assessment.
- If an in-flight landing performance assessment is not required, landing-performance-relevant information (e.g., a locked reverser or a failed autobrake) may not be considered or may be inappropriately considered by a flight crew during their approach preparation or following a late runway change (e.g., due to fatigue, distraction, complacency).
- Weather situations and/or runway status can change, sometimes more quickly than expected by flight crews and air traffic controllers, leading to the landing performance being limited on a runway, even if previous calculations did not show this. Consequently, flight crews might risk landing on a runway which does not provide an adequate stopping margin if they did not assess in advance what their actual limits for landing on a specific runway are, as the following example highlights:

  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 into account the actual weather (i.e., runway dry, no wind component) or they consider the possibility 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 10 kts tail wind.

  The first option is the more favourable case (in terms of short-time economic considerations) but does not prepare the crew for the decision to be taken in the event of weather deterioration on short final. The second option will allow the crew to assess whether the landing can be conducted safely in the worst case (e.g., what is the maximum tail wind and the worst runway condition that they can accept). Thus, if on final, ATC says the conditions are 'runway wet and 230/15 gusting 20 clear to land runway 33', the decision to land or not will be based on a sound performance calculation in the case of the second option and on guesswork only in the case of the first option.

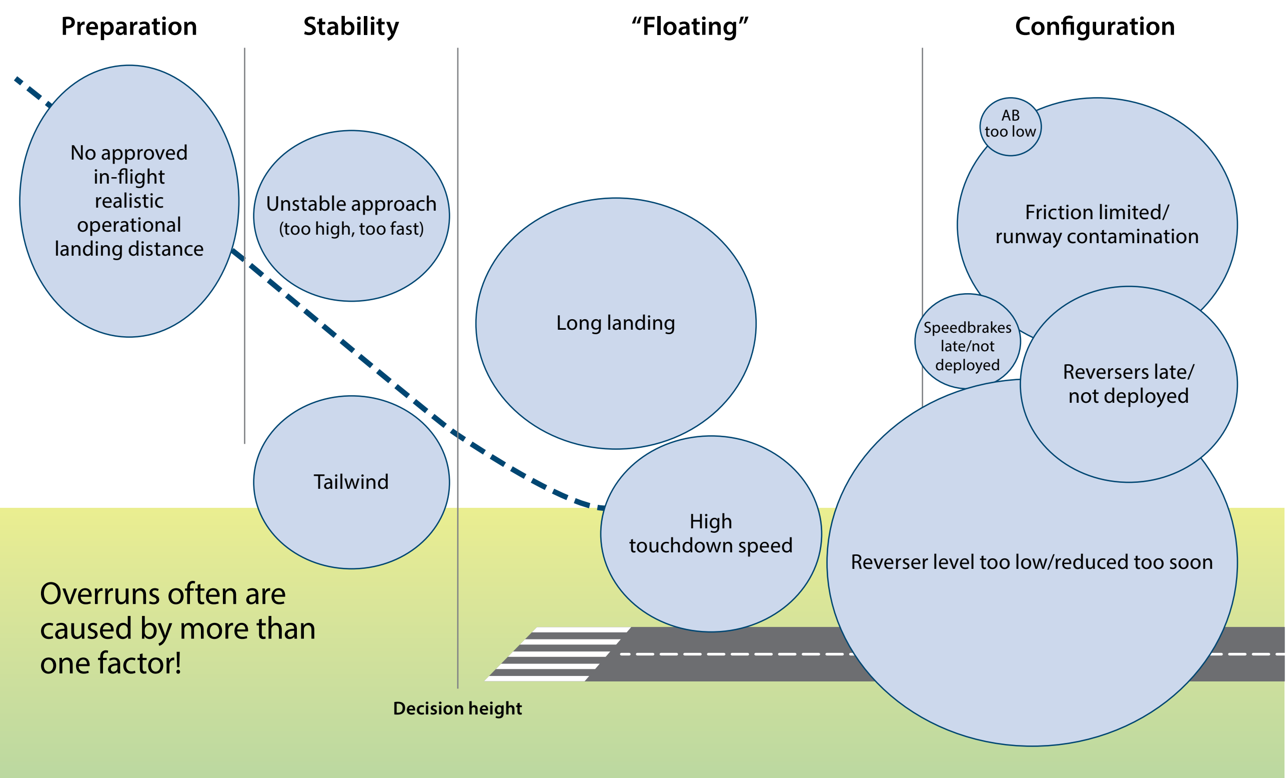
While most flight crews are familiar with the dispatch requirements on landing performance which are based on unfactored actual landing distances (ALD), multiplied with a regulatory factor, it is important that flight crews are aware of when manufacturers are basing their in-flight landing performance on unfactored or factored operational landing distances (OLD), and that they know and understand which safety factors their operator has implemented, both for normal and for non-normal conditions. This is especially important for flight crews when landing on a short (e.g., £ 2500 m/£ 8200 ft), slippery wet or contaminated runway.

Considerations regarding the correct use of stopping devices

On top of the considerations above, there are further threats which could contribute to a reduction or disappearance of the safety margin leading to runway excursions. Figure 13 (p. 90) gives an overview of frequent contributing factors to runway overruns. It shows that especially after touchdown, some specific factors influencing the stopping margin (e.g., a late or inadequate use of stopping devices) may significantly aggravate the risk of a runway overrun.

The other reasons behind such flight crew errors are very often not aircraft system malfunctions but systemic deficiencies like improper flight crew training, improper or missing SOPs or TEM guidance, or even complacency by flight crews. Organizational pressure driven by economic reasoning may influence a flight crew's decision-making not only on approach (e.g., to land instead of going around) but also during the landing roll. The use of reverse thrust above idle or heavy braking in the high-speed portion of the landing run might have become a less common practice among flight crews (e.g., due to considerations on fuel savings and brake wear, noise abatement requirements at airports or passenger comfort reasons). Consequently, there is currently a risk in the industry that flight crews may feel

Figure 13. **Overrun characteristics**



Source: International Coordinating Council of Aerospace Industries Associations

inhibited or reluctant to make full use of all deceleration means upon landing. The resulting runway excursion risk can be mitigated if flight crews know and understand the assumptions which underlie the results of their landing performance calculations (e.g., if any reverse thrust or maximum manual breaking is required to achieve the calculated stopping performance). Additionally, aircraft operators should encourage and provide flight crews with the freedom to ignore any noise, economic or ATC requirements whenever they deem it necessary to maintain their safety margin.

In order to ensure that the incorporated safety factors can provide the expected stopping margin, flight crews need to understand that they must apply the necessary procedural steps (e.g., brake application, spoiler and reverser activation) in the assumed time and to the expected extent in order to keep deviations from the reference conditions as small as possible — especially in situations when operating near or at the calculated landing performance limit. Moreover, with regard to the safety factors used, it is important for flight crews to know that in some cases, the results of landing performance calculations are advisory only (e.g., contaminated landing performance on some aircraft). This means they are calculated only and not flight-tested, so that it depends on the manufacturer or company policy which additional margin, if any, is or has to be applied to provide an additional safety margin in practice.

Incident and accident reports often reveal that flight crews, controllers and airport operators tend to overestimate the actual runway friction capability and underestimate the influence and presence of factors which could lead to reduced stopping performance (e.g., rubber build-up; polishing or puddling due to heavy rain or poor drainage; prolonged flare due to crosswinds; the need to reduce reverse in crosswinds, etc.). Although the new ICAO GRF will introduce an improved set of measures for determining runway status, its application still relies on human assessment and continuous critical review by operations personnel or AIREPs/PIREPs by landing flight crews. (AIREPs are defined by Eurocontrol as reports from aircraft in flight that are prepared in conformity with requirements for position, and operational and/or meteorological reporting.) As this might not always be a given in practice, especially in challenging and rapidly changing weather situations, and not all runways provide good braking action when not dry, it should be obvious that flight crews should be required to always assess the weather using a conservative strategy. This applies in particular to the runway condition and the wind component as well as to the crews' making full use of all deceleration means when landing on a slippery wet, slippery or contaminated runway, irrespective of any noise or other restrictions unless they cause controllability issues.

What can aircraft operators do to implement the recommendation?

Whether flight crews can effectively prevent runway excursions in their flight operation or not depends largely on aircraft operators' policies, SOPs and training with regard to landing performance. The following should be considered when establishing such SOPs and training practices:

- Aircraft operators' policies and SOPs should clearly highlight that landing at the originally planned destination is not the default option for a flight, but that go-arounds, diversions or even flight cancellations are encouraged if flight crews do not consider it safe to start an approach or to land at the destination airport. Aircraft operators can do this by requiring flight crews and dispatchers to always base their assessment of landing performance on a conservative strategy, in particular concerning the assessment of the runway condition and wind components, even if this leads to go-arounds, diversions or flight cancellations. This operational conservatism should incorporate policies or SOPs which allow a flight crew to further reduce operational limits (e.g., crosswind, tail wind or weight limits), whenever they deem it necessary. (See *OPS 11* and *OPS 29*.)
- Performance calculation at the time of landing preferably should be performed during the approach preparation in cruise flight before reaching the top of descent. It should take into account the actual aircraft status (e.g., MEL items like an inoperative thrust reverser, failure of autobrakes or auto-spoiler), the most realistic landing weight and the latest weather and runway information available. Flight crews should be required to always assess the weather using a conservative strategy, in particular with regard to the runway condition and the wind component. In order to cover deteriorating weather trends or sudden runway changes, flight crews should be required to conduct a worst-case analysis to define the performance limits for a landing (e.g., in terms of maximum crosswinds or lowest braking action value allowed [canned decisions]), as well as a calculation for realistically expectable conditions (e.g., for planning the expected runway exit).
- In order to support flight crews in assessing the landing performance correctly, aircraft operators should provide unambiguous landing performance information. At least the following information concerning the landing performance data should be provided to flight crews:
  - What level of reverse thrust was assumed;
  - The assumption of the wheel braking;
  - Whether the data was factored or not;
  - If the data was factored, then by what amount; and,
  - What the air distance allowance in the data was.
- Aircraft operators' TEM guidance with regard to runway excursion prevention should require flight crews to always brief and agree on at least the following seven items:
  - The type of braking intended to be used (e.g., autobrake setting, manual or no braking);
  - The amount of reverse thrust to be used (e.g., idle, intermediate or full);
  - The additional stop margin available* (after application of all safety factors) and those limits resulting from the in-flight assessment of the landing performance (e.g., maximum tail wind or crosswind limits which are below the flight crew operating manual's[FCOM's] values);
  - The limits set by the crew, if different from given operational limits or if airport/aircraft specific;
  - The touchdown point limits (see *OPS 21*);
  - The planned runway exit and expected taxi-in, including the expected surface condition; and,
  - Factors which may lead to a reduction in the stop margin (e.g., crosswinds, single reverse only, high Vref wind increments, thermal effects).

  Briefing these items will not only lead to improved team decision-making prior to and during the approach and landing but also enable the PM to effectively monitor and provide timely advice or intervene if he/she observes any changes in environmental conditions or a lack of activation of the required stopping devices upon touchdown (e.g., no automatic ground spoiler activation or no or insufficient reverse thrust). Furthermore, using the method of 'canned decisions' (i.e., what will we do if this or that happens, setting clear decision gates) makes it possible to determine up to what level of deterioration a landing can still be safely accomplished and enables the flight crew to agree on definite limits and clear gates for the continuation of the approach or landing (e.g., maximum crosswind or tail wind limits, minimum visibility or runway friction values). This makes it easier for the PM to effectively monitor and intervene, irrespective of rank and experience.
- Aircraft operators should consider incorporating a policy or SOP clearly stating that flight crews are allowed, and are encouraged, to disregard any noise abatement restrictions or to refuse any ATC instructions when they deem it necessary for safety reasons. This should incorporate the requirement to make full use of all deceleration means when landing performance is limited, both on actual or assumed slippery wet, slippery or contaminated runways, unless this causes controllability issues.
- Aircraft operators' philosophy and policies with regard to the role of the PM should clearly specify that the function of the PM includes monitoring, providing directive assistance and both passive and active intervention. Passive intervention requires the PM to make callouts, including callouts on items missed by the PF upon touchdown. However, in the event that the PF does not react in time, the PM is required to actively intervene, for example, by taking over control. With regard to landing performance and runway excursion prevention, the following items should be monitored by the PM, specifically:

* Aircraft operators might choose to categorise their landings by analogy with the remaining stop margin available (e.g., orange landings if the difference required between LDA and OLD is less than 400 m/1,200 ft, or red landings if the difference is only 200 m or less) in order to simplify flight crews' risk awareness when landing on performance critical runways. These values may of course change depending on the aircraft type used.

› Stabilised approach criteria to be maintained until touchdown, with a special focus on airspeed;

› Touchdown within and before the defined lateral touchdown limit;

› Immediate or timely brake application, depending on the selected braking method;

› Immediate deployment of ground spoilers;

› Immediate and symmetrical application of thrust reverse, if required; and,

› Centreline adherence and remaining stopping margin.

On top of monitoring the technical tasks of the PF, it is critical for the prevention of runway excursions that the PM also monitors, assists and intervenes in the PF's safety-relevant decision-making, irrespective of rank or experience. Preventing runway excursions requires clearly safety-oriented team decision-making, which means that it should always be based on a conservative strategy, in particular when assessing the runway condition, wind components and the flight crew's ability to land safely. Therefore, aircraft operators' policies and SOPs should, in normal operation, require the PIC to always choose the more conservative option as deemed necessary by any flight crew member (including enlarged crew) and to accept any interventions by the SIC which provide a greater safety margin for the approach and landing. This should include all decisions regarding the approach and landing but should not affect the PIC's emergency authority in the event of (impending) abnormal or emergency situations.

- Aircraft operators' flight crew training is crucial for the effective prevention of runway excursions in their flight operation because it fosters the implementation of their policies and SOPs and can support their flight crews in understanding the sensitivity of the topic of landing performance and its associated safety aspects. While ensuring that flight crews have adequate knowledge and understanding of how to prevent runway excursions, their training should strive to make them confident in dealing with complex or challenging weather and landing situations. It should also, however, promote the required conservative mind-set, enabling flight crews to easily decide on go-arounds or diversions, if required. This can be trained by means of line-oriented flight training (LOFT) sessions as well as specific runway excursion prevention lessons in the recurrent simulator and CRM/TEM trainings. These should include the following topics:

› Team decision-making based on a conservative assessment of landing performance calculation results;

› Go-arounds from various situations (e.g., due to unstable approaches below the approach minimum, due to changing weather leading to approaching or exceeding limits);

› Intervention scenarios, including taking over control before and after touchdown; and,

› Landing and braking on different runway surface conditions.

Training flight crews should be reminded of the importance of showing conservative behaviour in practice in order to be good role models for runway excursion prevention. Furthermore, aircraft operators' theoretical and recurrent training for runway excursion prevention should focus on at least the following topics:

- The use of ground spoilers/speed brakes

Ground spoilers primarily reduce lift and increase drag. Reducing lift increases the weight on the wheels, and thus improves braking performance. The effect of the ground spoilers is even greater on wet or contaminated runways, where brake performance is already lower, and the risk of aquaplaning is increased. Ground spoilers are usually automatically extended, and their automatic extension should be monitored by flight crews. If they do not extend, a callout should be made by the PM and where possible, they should be extended manually without delay, either by the PF or PM.

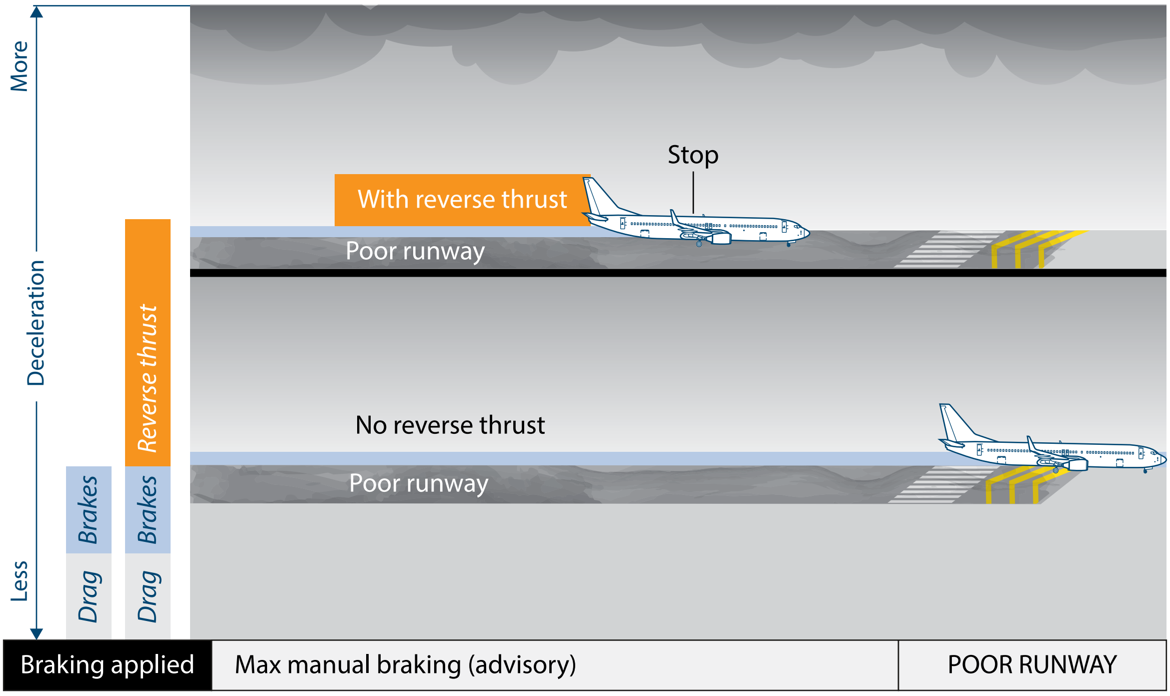
- The use of reverse thrust

The deceleration effect of thrust reversers is more effective at high speed, so the selection should be made as soon as possible, generally at main landing gear touchdown. The reverse thrust should be maintained until a safe taxi speed is achieved or the stop is assured, all the while considering the controllability effects of crosswinds and the possible reduction in visibility if snow is blown up in front of the aircraft. 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. Similar to ground spoiler extension, the immediate, correct and symmetric application of reverse thrust should also be monitored by the PM. The importance of monitoring symmetric deployment should be emphasised, especially during flight crew training. If dispatch with a thrust reverser locked out is permitted and use of a single reverser is permitted, then an explicit SOP for its use should be provided.

- The use of brakes/autobrake

Selecting an autobrake level means selecting a deceleration rate rather than a braking effort. Selecting reverse thrust with an autobrake 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. Selecting reverse thrust on a dry runway provides minimal additional deceleration with maximum manual braking and no additional deceleration with autobrakes. 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.

Figure 14. **Additive thrust reversers**



Special considerations for landings on runways with a braking action of less than medium

Many runway excursion incidents and accidents happen on runways providing only medium or even less breaking action (e.g., GRF RCC 2 or 3). Landing on runways with a braking action of less than medium should therefore be treated with reluctance both by aircraft operators and flight crews.

Flight crews are confronted with adverse weather (e.g., heavy rain showers or severe winter operation), leading to runway conditions providing less than medium braking action. Aircraft operators should consider individual risk assessments for the use of these airports as destination or destination-alternate airports and provide valuable information in their airport briefings or operational flight plans for their flight crews — e.g., with regard to PIREPs or frequently made mistakes, special (orographic) factors which influence speed control on short final, general weight limitations based on the risk assessment.

In such special cases, the need cannot be overemphasised for an immediate, symmetrical and full use of reverse until reaching a safe taxi speed or full stop is assured. As Figure 14 shows, when using maximum manual braking, thrust reversers are additive. While deceleration due to drag does not change for all runway conditions, the deceleration effects from reverse thrust increase significantly; brake efficiency decreases due to slippery runway conditions.

(See *R&D3.*)

4.3 Runway and approach type selection (OPS 17)

Recommendation OPS 17: Aircraft operators should require the flight crew to carefully evaluate operational safety before selecting/accepting an approach and landing runway including the following: weather conditions (in particular cross- and tailwinds), runway condition (dry, wet or contaminated/slippery), inoperable equipment, and aircraft and flight crew performance in order to reduce runway excursion risks.

Why should aircraft operators follow this recommendation?

The type of operation (normal or non-normal) may influence a flight crew's safety-relevant decision-making. Being operationally conservative (e.g., by requesting another approach, a longer runway or a runway offering better wind conditions) is often easier for flight crews in non-normal operation (e.g., in cases when an aircraft has a technical failure or an emergency) than in normal operation, because the need for the request is obvious and thereby easier to justify to air traffic controllers as well as to the aircraft operator's management. Nevertheless, threats like tail winds or crosswinds, fatigue, reduced or lack of approach/runway lighting, a non-precision approach, lack of proficiency, etc. may lead to the same critical reduction in the safety margin for a flight as a major technical failure would. Therefore, there should be consensus in the industry that flight crews, who have final authority over the safe operation of their aircraft, should have the freedom to always choose the type of approach and landing runway which provide the highest level of safety and operational assurances for their flight, especially with regard to runway excursion prevention. The risk appetite for a given situation may differ according to individual flight crews and their aircraft and its performance, equipment or technical status, as well as the individual human and team factors on the flight deck, such as the pilot's proficiency, airport familiarity, fatigue levels or type of flight (e.g., training, check or maintenance test flight). Consequently, some flight crews may be able to accept a specific approach or landing runway whereas others may not. There should be no pressure on flight crews (e.g., due to traffic, capacity, schedule, noise or other reasons) to fly approaches and attempt landings which expose them to runway excursion risks which they are not able to control safely.

What can aircraft operators do to implement the recommendation?

Aircraft operators can support their flight crews in preventing runway excursions by providing them with policies or SOPs that encourage and embolden them to withstand any economic or other peer pressure which could lead to unsafe decision-making. This is especially important when selecting the landing runway and the associated approach. The following should be considered when establishing such policies or SOPs:

- Aircraft operators should require flight crews to critically assess during their approach preparation and continuously during their arrival whether the landing runway and associated approach in use can still assure a landing with sufficient safety margin to prevent a runway excursion (operational safety). This assessment should be accomplished jointly by the flight crew using a conservative strategy and be based on at least the following five items:
  - The runway length, width and surface condition, including deteriorating trends (e.g., during winter operation or in heavy rain showers);
  - The weather at the time of arrival, especially with regard to wind components, precipitation and icing, considering also deteriorating trends;
  - The aircraft status, including the landing performance in relation to the gross weight at the expected touchdown time, the functionality of deceleration devices and the equipment available for approach (e.g., area navigation/ required navigation performance [RNAV/RNP]);
  - The flight crew's status in relation to fitness, proficiency, airport and aircraft/variant familiarity as well as the individual work atmosphere; and,
  - The alternative options available at the airport in terms of approaches and landing runways available.
- Aircraft operators should allow and encourage flight crews to choose the approach and runway which provide the highest level of safety and operational assurances based on their own individual local rationality, even if this leads to delay, increased fuel consumption or the violation of noise restrictions. Flight crews should be allowed and encouraged to cater for such circumstances if they are able to anticipate such threats (e.g., by taking extra fuel or accepting delay on approach). Policies should make clear that decisions concerning approach and runway selection should always be joint flight crew decisions based on the most conservative option as preferred by either flight crew member, unless a non-normal or emergency situation may require the PIC to decide otherwise.
- Aircraft operators should require flight crews to generally prefer 3D approaches over 2D approaches and, where deemed applicable, to always use the highest level of automation in order to reduce crew workload and increase the flight crew's situational awareness. However, aircraft operators' policies and SOPs should provide guidance for their crews on the circumstances and accompanying precautionary measures under which deviations from the above are allowed (e.g., to maintain the proficiency of manual flying skills for flight crews). This may include restrictions like the necessity to brief and agree on the use of manual flight in the approach briefing, imposing requirements to also use partial automation (e.g., auto thrust) and to require reversion to automatic flight as soon as requested by the PM to safely cope with complex situations and avoid task overloading (e.g., during final approach or base turns with simultaneous configuration changes, checklist reading and ATC calls).
- Aircraft operators should support flight crews by proactively exchanging information with ANSPs and airport operators on airports in their route network where tail wind/crosswind operation is prevalent (e.g., in combination with relatively short runways) or to explain why flight crews might need to request approach and/or runway changes (e.g., during local runway safety team meetings or via their commercial contacts).

4.4 Autoland without protection of ILS critical/sensitive areas (OPS 20)

Why should aircraft operators follow this recommendation?

Although use of the autoland capability of an aircraft, if installed and approved, can aid a crew in landing safely under protected conditions (e.g., during low visibility operation), this method may pose significant threats to a flight when used without protected ILS critical/sensitive areas. The reason for this is that rapid and unpredictable signal deflections from localiser or glideslope antennas may be induced by any aircraft or vehicle which is positioned in or crossing the critical and sensitive areas, leading to unpredictable autopilot behaviour, which may be catastrophic at very low altitudes

Recommendation OPS 20: Aircraft operators should publish SOPs and guidance their flight crews not to conduct auto-land approach manoeuvres at airports when low visibility procedures (LVP) are not in force, unless:

- the ILS critical and sensitive areas are protected,
- ATC had been informed and reassurance of ILS sensitive area protection had been received

or

- specific precautions have been taken and risk analysis has been performed.

or

- the aircraft is demonstrated as robust to non-protection of ILS sensitive area.

and during landing rollout. The best-known example of such an event was an accident in Munich in 2011 when a Boeing 777 veered off the runway. Although manufacturers generally allow the practice of autoland approaches without protected critical and sensitive areas under the assumption that flight crews could take over manually in case of flight path deviations, this option should be used with the greatest reluctance and only under very special and risk-assessed conditions. Depending on the aircraft type and the point of reversion to manual flight, the aircraft may be inadequately trimmed for manual flight, the flight crew might not be aware of the actual aircraft status and its go-around capability, the flight crew's cognitive performance may be reduced by fatigue or surprise/startle, or there may be a risk of approach instability by large and abrupt control inputs, which may, in turn, lead to unnecessarily complex situations in close proximity to the ground.

The autoland function of an aircraft is a safety feature which allows the flight crew to ensure safe landings either in degraded weather situations or in the event of degraded flight crew abilities to safely fly the airplane manually, (e.g., due to fatigue, lack of proficiency or incapacitation of a crew member). However, this requires certain conditions to be met, including proper ground protection, a certain wind envelop or other aircraft-type-specific restrictions.

What can aircraft operators do to implement the recommendation?

Flight crews need proper training and safe policies/SOPs enabling them to ensure safe autolands. When establishing such SOPs and training practices, aircraft operators should consider at least the following:

- Aircraft operators should restrict the use of autoland to conditions when the ILS critical/sensitive areas are protected. This should apply to both routine line flights and training flights.
- Aircraft operators should require flight crews to consider during their pre-flight preparation whether an autoland may be required or desired for landing (e.g., due to weather or human performance limitations). In such cases, the flight crew should ensure that the airplane carries sufficient fuel for possible delay/holding in case protection of the ILS critical/sensitive areas cannot be guaranteed by ATC at the estimated arrival time.
- Aircraft operators should require flight crews to advise ATC as early as possible of the need for protected ILS critical/sensitive areas during approach and landing, as the necessary traffic spacing and system setup may take some time. Before starting the autoland approach, the flight crew should have received acknowledgement by ATC that the protection has actually been given during their landing.

The protection of ILS critical/sensitive areas is currently the most effective measure to mitigate the risk of signal disruptions during autolands. If aircraft operators consider using the autoland function in their operation without any ground protection (e.g., during certification processes or in marginal weather conditions), they need to prove to their regulator in a safety case or formal risk assessment that any proposed alternative guarantees at least the same level of safety as the ground protection. At least the following should be considered for such a risk assessment:

- The aircraft operator should check that the ILS beam quality and the effect of terrain profile before the runway have no adverse effect on autopilot/flight director (AP/FD) guidance. In particular, the effect of terrain discontinuities within 300 m before the runway threshold have to be evaluated.
- The aircraft operator should consider the amount and scope of training needed to train flight crews in safe aircraft recovery in the event of autopilot misbehaviour and offsets due to signal disruption, especially at low level and during touchdown and landing rollout. Therein, flight crews should be made aware that localizer (LOC) or glideslope (GS) beam fluctuations, independent of aircraft systems, may occur, and the PF must be prepared to immediately disconnect the AP and take appropriate action should unsatisfactory guidance occur. This should also include establishing proper intervention SOPs (e.g., go-around call) and initiation by the pilot detecting signal disruptions first (this may be the PM or PF) and the provision of practical training in the simulator.
- The aircraft operator should consider the simulator representativeness (i.e., whether such failures or disruptions can be realistically simulated.
- The aircraft operator should specify clear limits and restrictions for the use of autoland without protected areas (e.g., with regard to weather, daylight, aircraft systems or

information from ATC about the intended landing using autoland without protected areas). As an example: On an Airbus aircraft, at least CAT2 capability should be displayed on the flight mode annunciator, and CATII/III procedures should be used. Visual references should be obtained at an altitude appropriate to the performed CAT I approach; otherwise go-around should be initiated.

- The aircraft operator should seek guidance from the aircraft manufacturer regarding possible tools to make the aircraft robust to non-protection of ILS sensitive areas by technical means (e.g., the Airbus Exact Landing Interference Simulation Environment (ELISE) software for airports and ANSPs), which can effectively eliminate interference to an ILS due to aircraft, vehicles, buildings and other objects in close proximity to the runway.

4.5 Stabilised approach and landing (OPS 18, 19, 32)

Recommendation OPS 18: Aircraft operators should clearly define stabilised approach, landing and go-around policies in their operations manual. These policies have to be aligned with regulations requirements and manufacturers guidance. Supplementing SOPs should include the requirement for completion of the landing checklist and flying with the final approach speed latest at the defined approach/landing gate. These SOPs should include appropriate means for the pilot monitoring (PM) to effectively monitor and, if needed, intervene. To properly implement the defined policies and SOPs, aircraft operators have to deliver appropriate training.

Recommendation OPS 19: Aircraft operators should publish SOPs and guidance and provide training highlighting the importance of active monitoring and effective intervention by the pilot monitoring (PM) during descent, approach, approach path management and landing. Actions to be taken by the PM and required reactions by the PF should be clearly documented in the official publication (e.g. SOPs or Operations Manual, FCOM, etc.). These publications should include guidance how to achieve effective PM performance, independent of rank and experience.

Recommendation OPS 32: Aircraft operators should:

1) Define an unstable approach followed by landing as a mandatory reporting event by the flight crew and
2) Minimise the need to report a go-around due to an unstable approach unless there is another significant event in relation to the go-around, e.g. flap overspeed.

Why should aircraft operators follow this recommendation?

It is well accepted throughout the industry that a prerequisite for a safe landing is a stabilised approach. All worldwide applicable regulations like ICAO Procedures for Air Navigation Services – Aircraft Operations (PANS OPS), Doc 8168, or IATA Operational Safety Audit (IOSA) standards, as well as national regulations, clearly demand stable approach policies and implemented the criteria for a stable approach concept as sparked by the Flight Safety Foundation Approach and Landing Accident Reduction (ALAR) Tool Kit more than 20 years ago.

Nevertheless, there are still flight crews in today's worldwide flight operation taking the risk of continuing to land from an unstabilised approach. Flight crews need to be made aware of the risks associated with unstabilised approaches, especially in regard to runway excursion prevention. Continuing to land from an unstabilised approach, even though the landing might be perceived as uneventful, is a safety-critical event. According to a safety study by IATA on accidents in the period from 2012 to 2016, an average of six accidents per year were preceded by an unstable approach. The analysis also revealed that unstable approaches were cited as one of the contributing factors in 50 percent of hard landings, 27 percent of runway/taxiway excursions, 9 percent of tail strikes, 6 percent of undershoots, and 3 percent of loss of control, of in-flight damage or of controlled flight into terrain. As runway excursions are still one of the key risk areas in aviation, and as shown by the preliminary figures regarding the latest accidents in 2019 and 2020, there is still a strong need across the industry to support flight crews in complying with stable approach policies in daily practice.

Although the criteria which define a stable approach may differ among aircraft operators, depending on their type of operation, their route network or type of aircraft used, the common key element is the requirement for a go-around if an approach or landing becomes destabilised at or below the stable approach gate. The problem, faced in particular by commercial aviation today, is that there might still be barriers in the aviation system which lead to a reluctance among some flight crews to call for or to execute go-arounds (see recommendation *OPS 16*). At the same time, capacity and approach management is sometimes efficiency-oriented instead of safety-oriented. Therefore, the strategy for the industry to cope with the problem of 'unstable approaches – landed' should be twofold:

- It should be made as easy as possible for flight crews to achieve stable approaches; and,
- It should be made as easy as possible for flight crews to execute a go-around if their approach becomes destabilised.

Achieving stable approaches as well as go-arounds from unstable approaches requires a joint effort and collaboration throughout our industry. While regulators, aircraft manufacturers, ANSPs, aircraft operators and training organisations can influence flight crews' stable approach performance by providing useful policies, approach procedures, SOPs and training, frontline personnel like flight crews and ATCOs can achieve stable approaches by applying a defensive/conservative strategy in their energy and traffic management and by strictly adhering to SOPs and limitations, as well as through early mutual intervention, if required.

(Early) intervention in particular is a key to achieving stable approaches and to preventing 'unstable approaches – landed', thus reducing the risk of runway excursions significantly. An unstable approach often largely originates prior to starting the approach (e.g,. due to hot and high approach vectoring by ATC, energy mismanagement by the PF or the flight crew's lack of or inappropriate threat analysis with regard to relevant threats like significant tail wind components or restrictions associated with weather, terrain or traffic during descent.

Many runway excursion events involve the aircraft flying higher or lower than the desired vertical flight path and/or faster or slower than the desired airspeed. Therefore, the role of the PM (and other qualified flight crew members on the flight deck, if available, like supernumerary or enlarged crew) is not only of paramount importance throughout the approach phase but also during the descent.

Contrary to hard intervention measures on final approach, like calling for a go-around or taking over control from the PF (which may require tremendous psychological effort for the PM, depending on the cross-cockpit authority gradient, the cockpit's work atmosphere or the airline's culture and its training quality), the PM has various opportunities in the descent, arrival and initial approach to use soft intervention measures, like deviation callouts, rejecting shortcuts by ATC or using nudges vis-à-vis the PF. Nudges are interventions that preserve the freedom of choice but that nonetheless influence people's decisions. Human decisions are often heavily influenced by cognitive and behavioural biases. We tend to favour default options, to make contextual instead of objective decisions and we are deeply affected by social norms. Therefore, nudging is an elegant and useful tool which can be used either within the flight deck team or in the team formed by the flight crew and the relevant ATCO.

Achieving a stable approach is a collaborative effort by the PF, PM(s) and ATCO(s) which requires that mutual intervention between flight crews and ATCOs, as well as mutual intervention within the flight deck team, is accepted by all team members. The old notion of 'my leg, your leg' (single-pilot attitude on the flight deck whereby the PM is viewed merely as an assistant to the PF) or the idea that ATC is not responsible for an aircraft's energy management are counterproductive to achieving safe descents, approaches and landings, and thus to preventing runway excursions. In order to provide appropriate intervention throughout the descent and approach, the following nudges could help to ensure that neither the PM, nor the PF or ATCO, feel uncomfortable or lacking in confidence when it comes to the safe operation of the aircraft (Table 2).

With regard to achieving stable approaches, it is worth noting that there might still be significant differences between flight crews' and ATCO's perspectives on safe aircraft operation. As ATCOs handle many different types of aircraft which are operated by many different aircraft operators, it is sometimes hard for them to understand why some flight crews require more mileage or declare 'unable', while others seem to be able to follow their instructions, especially if dealing with aircraft types belonging to the same approach category (e.g, A320 and B737). If ATCOs could see that flight crews sometimes undertake unsafe practices, such as flying near or at the edge of their operational speed and flap envelope, diving for the required descent path with high nose down pitch, extending the gear early just to be able to reduce their speed below flaps extension speed or risk flying high speed in low level, only to heed ATC instructions, ATCOs would maybe refrain from providing challenging clearances. Moreover, the influences of varying descent and speed reduction capabilities of different aircraft types and the influences of different gross weights or tailwind components also need to be considered. Therefore,

Table 2

Nudges between the PM and PF	Nudges between the flight crew and ATC
Asking/advising the PF on the use of speed brakes;	Pilot: asking ATC for the planned track miles to go;
Asking/advising the PF on the estimated shortest distance to go (even at regular intervals);	Pilot: advising ATC on the required track miles to go;
Stating out loud actual wind or gross weight and its influence on the descent path; and,	ATCO: stating the planned track miles to flight crews on initial contact or asking for the required track miles; and,
Calling out anticipation of an unstable approach.	ATCO: asking/challenging flight crews if their approach path or approach speed appear higher than usual.

there should be consensus in the industry that flight crews, who are ultimately responsible for the safe operation of their flights, have the right to intervene in ATC instructions, and that ATCOs have the right to intervene in flight crews' aircraft handling if they believe there to be any threat to a safe approach and landing (e.g., when flight crews intercept an approach path exceptionally high or fast).

In order to achieve acceptance of intervention among team members and to avoid this having a negative impact on the work atmosphere on the flight deck or damaging the reputation of aircraft operators among ANSPs, it is important that intervention methods and their associated expected and permitted reactions are documented and standardised. For nudges or soft interventions like deviation callouts, common wordings such as 'Checked', 'Roger' or 'Thank you' might be sufficient. However, for hard interventions like expressing concerns, calling for a go-around or taking away aircraft control, clear procedural guidance and training for flight crews is required. There are tools already in use by some aircraft operators like intervention cascades (e.g., 'I feel uncomfortable, I feel concerned, I feel unsafe', or the 'CUS' method which uses callouts like 'Concerned – Uncomfortable – Safety'. These have in common the fact that they are usable during all phases of flight. With regard to the descent, approach and landing phase, they can most certainly help assure stable approaches, too, but there are circumstances when only a go-around call or taking away control from the PF is the best option for the PM to prevent an accident.

The Foundation safety study on go-around decision-making reports that more than 50 percent of runway excursions follow a stable approach which becomes unstable after threshold crossing. This may happen due to wind shear, thermals, the PF's lack of proficiency, overcontrolling, fatigue, etc. In such cases, it is important that flight crews initiate a go-around, even during flare and touchdown (until the selection of reverse thrust) instead of forcing a landing. Effective intervention by the PM in such situations by calling for a go-around or even by taking away controls from the PF in order to initiate the go-around may be necessary. According to a joint paper on stable approaches by IATA and the International Federation of Air Line Pilots' Associations (IFALPA), the idea that either pilot can call for a go-around is an essential part of CRM, which is the core concept of TEM, and in fact should be an important element in an aircraft operator's TEM training (IATA, 2016). The circumstances for such intervention by the PM should be clearly stated in the SOP, and appropriate guidance and training should be provided which also highlights possible differential risk perception of the PF/PM, depending on whether the role of the PF is fulfilled by the PIC or the SIC. Training for taking over control from the PF safely (e.g., in case of macho behaviour (not accepting a go-around call) or (subtle) incapacitation, possibly by fatigue, startle or tunnel vision of the PF, should be included already in the initial pilot and type rating training and should also be a standing topic of recurrent simulator training for all flight crews, irrespective of rank and experience.

What can aircraft operators do to implement the recommendation?

Aircraft operators should provide flight crews with policies, procedures and training which make it as easy as possible for them to conduct stable approaches and as easy as possible to decide for a go-around in the event that the approach or landing becomes unstabilised. The following should be considered when establishing the associated policies, SOPs and training practices:

Aircraft operators should define a combined stable approach and landing policy, making clear that certain stable criteria must be met until touchdown. The guidelines and limitations should make operational sense for both flight crews and management, resulting in greater acceptance of the policy. The final report of the FSF Go-Around Decision-Making and Execution Project (FSF, 2017) or the third edition of IATA's unstable approach paper (IATA, 2017)[10] may include useful hints and ideas. If aircraft operators are considering changing their stable approach SOP, it may be advisable to run an awareness campaign to explain the philosophy behind the new SOP. Examples of incidents or accidents that could have been prevented with the SOP would certainly strengthen its case. In general, at least the following items for defining a stable approach SOP should be considered:

- **Definition of approach gates**

  In order to always achieve a stable approach, the following gates could provide helpful guidance for flight crews. The following values for medium to large aircraft (e.g., A320/B737) may serve as an example (adaptions for different operations or aircraft type may be needed):

  - Last 18–15 nm from touchdown (depending on aircraft gross weight, wind, aircraft's speed reduction capabilities): reduction from 250 kts to 210 kts or minimum clean speed should be initiated;
  - Last 12 nm from touchdown: the aircraft should be flying at a maximum speed of 210 kts. A "12 miles to touchdown" callout by the PM could be a helpful tool to raise awareness for the PF, especially on approaches without a direct indication of mileage to the runway. Flight crews should be required to plan a level segment for further speed reduction and start of initial configuration;
  - Last 9 nm from touchdown/3,000 ft AAL: the aircraft should be flying at a maximum speed of 180 kts and on an initial flap setting;
  - Last 6 nm from touchdown/2,000 ft AAL: the gear should be lowered, and an intermediate flap setting selected, airspeed should be around 150 kts; and,
  - Last 3 nm from touchdown/1,000 ft AAL: final flaps should have been selected, landing checklist completed and the aircraft should have reached final approach speed.

[10] *https://www.iata.org/contentassets/7a5cd514de9c4c63ba0a7ac21547477a/iata-guidance-unstable-approaches.pdf*

Further check heights to help flight crew in their decision management are the outer marker/ fixed distance check, the stabilisation height, and 100 above/approaching minimum or minimum. Compliance with all required flight parameters within tolerance at one 'gate' means the flight can continue until the next 'gate', where again an assessment will 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 reverse thrust. Aircraft operators of aircraft without reverse thrust should define their own specific policy.

- **Criteria of a stabilised approach**

These must be clearly defined and easily assessable by the flight crew and should be reached by the latest at the stabilisation height. Examples could be:

1. **Aircraft is on the correct profile (lateral and vertical flight path)**:
    - CAT I ILS: aircraft within +/– 1 dot vertical path and localiser.
    - RNAV: within ½ -scale deflection of vertical and lateral scales and within RNP requirements.
    - Localiser/VHS omnidirectional radio (LOC/VOR): within 1 dot lateral deviation.
    - Visual: within the 'slightly high' and 'slightly low' indications visual approach path indicators and lined up with the runway centreline not later than 300 ft.
2. **Aircraft is properly configured to land**:
    - The aircraft is in the landing configuration (gear and flaps set, speed brakes retracted).
    - No more changes to a different flap setting due to unexpected wind change in approach.
3. **Aircraft is at the correct speed**:
    - Airspeed is stabilised within Vref + 10 kts to Vref (without wind adjustments).
    - Thrust is stabilised to maintain the target approach airspeed.

      Note that the use of an auto thrust system (ATS) for approach and landing can modify the previous recommendations. Aircraft operators should also specify whether it is possible to use the ATS without autopilot for approach and landing. If it is possible, they should promote the use of ATS in manual flying as it may reduce the pilot workload in monitoring speed and adjusting thrust, therefore freeing mental capacity for situational awareness. This may also prevent aircraft carrying excess speed over the threshold.
    - Sink rate is no greater than 1,000 fpm.
4. **Checklists completed**:
    - The landing checklist is completed. This will allow the PF to fully focus on flying duties and the PM to fully focus on monitoring duties.

› **General**:

- The stabilised approach gates should be observed, and the stabilisation height must be complied with.
- Normal bracketing corrections in maintaining stabilised conditions occasionally involve momentary overshoots made necessary by atmospheric conditions; such overshoots are acceptable. Frequent or sustained overshoots are not.
- Unique approach procedures or abnormal conditions requiring a deviation from the above elements require a special briefing.

› **Definition of stabilisation height**

Stabilisation heights are limits and 'must' gates where all of the stable criteria must be fulfilled at the latest. Flight crews should not view the stabilised height as a target as this may result in some overrun of the height. Common stabilisation heights used throughout the industry are 500 ft above the airfield elevation in visual meteorological conditions (VMC) and 1,000 ft in instrument meteorological conditions (IMC). Note that some operators use only the 1,000 ft requirement whatever the weather conditions. This not only simplifies the operating procedures but also simplifies the process for verifying compliance (e.g., by FDM) and is recommended to provide a better safety margin.

› **Actions at stabilisation height**

When passing the stabilisation height, the PM performs the compliance check and calls out the result (for instance, 'stable'/'not-stable'/'go-around'); the PF only has the choice between two possibilities: continue the approach or discontinue it, using the appropriate call out (i.e., 'continue' or 'go-around'. In the event that the approach is not stabilised, the PF must initiate a go-around manoeuvre. If the PF does not perform it, the PM has to take over control and perform the go-around. In such cases, SOPs should be provided for the PM to call all go-around–related memory items once actioned and include the required response/action if not performed by the other pilot.

› **Actions in the event of destabilisation below stabilisation height**

While the criteria and SOP mentioned before protect 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, thermals, lack of PF's proficiency, overcontrolling or fatigue. Provided the PF can regain the stabilised approach criteria, the approach may continue. During the later stages of the approach, the PF's focus usually shifts from inside the flight deck to outside. Depending on the level of automation used and the philosophy of the airline, either the PF or PM will start looking for the visual references needed to continue the approach beyond the decision height (DH). Monitoring for possible excessive deviations from path, speed, vertical speed, pitch or bank is crucial in this phase of transition from approach to landing as well as during flare and touchdown. Timely and effective callouts by the PM are necessary to guide and support the PF, who can easily become task saturated at this time and may not have the required capacity to exercise complex judgement. Especially in this phase, the PM should be ready to intervene hard by calling for a go-around or taking away control from the PF in order to go around in case deviations are excessive or the PF does not correct the deviations appropriately. This philosophy has consequences for the decision-making process and CRM; training is needed to enable the PM to consistently judge the situation and take the proper decision on short final.

- Aircraft operators should consider installing stable approach and energy management monitoring and alerting systems when available for the type of aircraft.
- Aircraft operators should implement an open policy on go-arounds, making a go-around a normal procedure and not an abnormal issue (see *OPS 16*).
- Aircraft operators' safety policies and commitments should contain a general requirement for frontline personnel to always use a defensive/conservative strategy in their safety-relevant decision-making. The role descriptions for the PIC and SIC should specifically contain the requirement for these roles to always use a defensive/conservative strategy in their flying and safety-relevant decision-making. This will foster a general safety-oriented flight operation which, in turn, will support their flight crews in achieving stable approaches while at the same time reducing the need for interventions and go-arounds.
- Aircraft operators should implement standardised intervention methods to be used by the flight crew both for mutual intervention within the cockpit team and towards ATC. These methods should be incorporated as SOPs in the aircraft operators' published operations manuals and should clearly describe when and how the PM should intervene, depending on the situation, including taking away control from the PF, and the permitted reactions by the PF. On the one hand, this will help to reduce barriers preventing the PM from using interventions appropriately without fear of jeopardising the cockpit work atmosphere ('nit-picking' or status considerations). It will also ensure timely and effective intervention which otherwise could be inhibited by the PM possibly worrying about performing an intervention too early (e.g., if the PM wants to give the PF time to correct, which may be inadequate in some situations. On the other hand, this will ensure that the reactions by the PF are appropriate (e.g., by correcting effectively, going around or handing over the controls without reluctance). An example of intervention cascades on top of the usual deviation callouts are the use of 'CUS' wordings by the PM like 'I'm concerned', 'I'm uncomfortable', 'This is a safety issue' or 'Stop the line'.[11] Other wordings might be useful, depending on the culture and maturity of the pilot workforce. The role description in the operations manual for the SIC and PM roles should include the authority for effective intervention, including taking away controls from the PF, if required, irrespective of rank and experience. Any intervention policy should incorporate additional crew members on the flight deck like qualified supernumerary, enlarged crew or training staff. The scope of intervention towards ATC should include the wording 'unable' as promoted by CANSO, the International Federation of Air Traffic Controllers' Associations (IFATCA) and IFALPA.[12] The topic of mutual intervention to guarantee stable approaches should be discussed jointly by aircraft operators and ANSPs (e.g., during local runway safety team meetings, or by inviting ATC personnel to attend the operator's CRM/TEM/accident prevention trainings.
- Aircraft operators' automation and checklist philosophy should require flight crews to plan configuration changes and checklist reading in such a way that the PM's tasks will not be impaired by task overloading, also taking into account requirements for ATC communication.
- Aircraft operators should define an 'unstable approach – landed' as an incident which must be reported by flight crews and which should be dealt with under just culture principles. The mandate to report go-arounds from unstable approaches should be restricted to those events where another reportable incident component was present (e.g., a flaps overspeed) in order to foster the attitude that the go-around itself is a normal procedure and is encouraged by the aircraft operator in all cases.
- Aircraft operators should use their safety promotion tools to continuously promote the stabilised approach principle and the need for defensive/conservative flying, as well as the need for early intervention and go-arounds, to their flight crews and management personnel in order to improve the buy-in of both groups to these concepts and to foster a mature safety culture. Compliance with the relevant policies and SOPs should be verified using means such as an FDM system which is guarded by a gatekeeper and air safety reports in line with just culture practices. An open reporting culture in the scope of the SMS will help to identify precursors to unsafe practices or design flaws in SOPs or approach procedures. Flight crews and

[11] CUS – method based on the approach of "TeamSTEPPS" (Team Strategies and Tools to Enhance Performance and Patient Safety), a healthcare solution for improving patient safety

[12] CANSO, IFATCA, IFALPA paper: *https://runwayexcursions.faa.gov/docs/Avoiding%20Unstable%20Approaches%20-%20Important%20Tips.pdf*

management should receive feedback on analytics and investigation results at regular intervals (e.g., bi-monthly).

- Aircraft operators' training on stabilised approaches should be provided in the simulator and in the classroom. Crews should not be allowed to fly unstabilised approaches during their simulator training. Instead training flight crews should encourage and reward defensive/conservative flying and decision-making. During simulator training, instructors should put the same emphasis on following the go-around procedures as in the real world. Their simulator training should contain intervention trainings covering various situations requiring soft and hard interventions by the PM, which should include various situations requiring go-around calls and taking away control from the PF. Such training should be given to every pilot irrespective of rank and experience. De-identified incidents from their airline or airline group should be used as examples during recurrent training to highlight the need for compliance with the stable approach policy and effective intervention, if required. This helps to show that incidents/accidents do not only happen to others. Using other real case studies may help to further increase understanding of the potential risk of a runway excursion after an unstabilised approach. The SKYbrary accident and incident database, among others, may serve as a library for such case studies.

(See *OPS 31* to include go-around/discontinued approach observation via FDM.)

4.6 Go-around policy, decision-making and pilot monitoring duties (OPS 16)

Recommendation OPS 16: Aircraft operators should develop a clear go-around policy which should be further supplemented by a set of SOPs and guidance materials to put this policy into action. This go-around policy should enable every flight crew member on the flight deck to call for a go-around at any time unless an emergency situation dictates otherwise. In all cases, the SOPs should require both pilots to have and retain the required visual reference below DA/MDA with a go-around call mandatory if either pilot loses it. A go-around should also be mandatory if the approach becomes unstabilised below the specified approach/landing gate.

Recurrent simulator training should be provided on the competencies of safe go-around in various stages during the approach and landing, including shortly prior or during touchdown (before activation of thrust reversers).

Why should aircraft operators follow this recommendation?

A go-around is a normal flight procedure. It is one of the most effective tools in aviation to prevent approach and landing accidents. A Flight Safety Foundation study of 16 years of runway excursions determined that 83 percent could have been avoided with a decision to go around. As approach and landing accidents account annually for approximately 65 percent of all accidents, as much as 54 percent of all accidents could potentially be prevented by going around (FSF, 2017).

For each aircraft, there are distinct procedures in place for performing a go-around safely, and at least each published instrument approach provides a predetermined and safety-risk-assessed go-around path and routing for approaching aircraft. Like other normal flight manoeuvres such as takeoff, approach or landing, go-arounds are mandatory manoeuvres in any pilot's initial and recurrent training/checking. Nevertheless, this safety tool may still, even in today's aviation, be stigmatised as being dangerous or undesired, when in fact the opposite is true.

It is even in the economic interest of airlines that their flight crews execute go-arounds, if required. Promoting of go-arounds will not only invest in the airline's safety culture but may prevent incidents and accidents in the long run (e.g., if a go-around prevents a hard landing which results in damage that could contribute to a landing gear event some years later, for example). Even in the short term, it is economically more desirable for an airline to use some fuel for a go-around instead of having to deal with the costs and negative outcomes of mishaps during landing (e.g., a hard landing, a runway excursion or an abnormal runway contact), which may not only have a significant impact on an operator's schedule but also may create huge follow-on costs, negative brand reputation or regulatory restrictions. Go-around compliance rates are therefore not only a key safety performance indicator for an aircraft operator's safety management but also a key performance indicator for aircraft operator's general management.

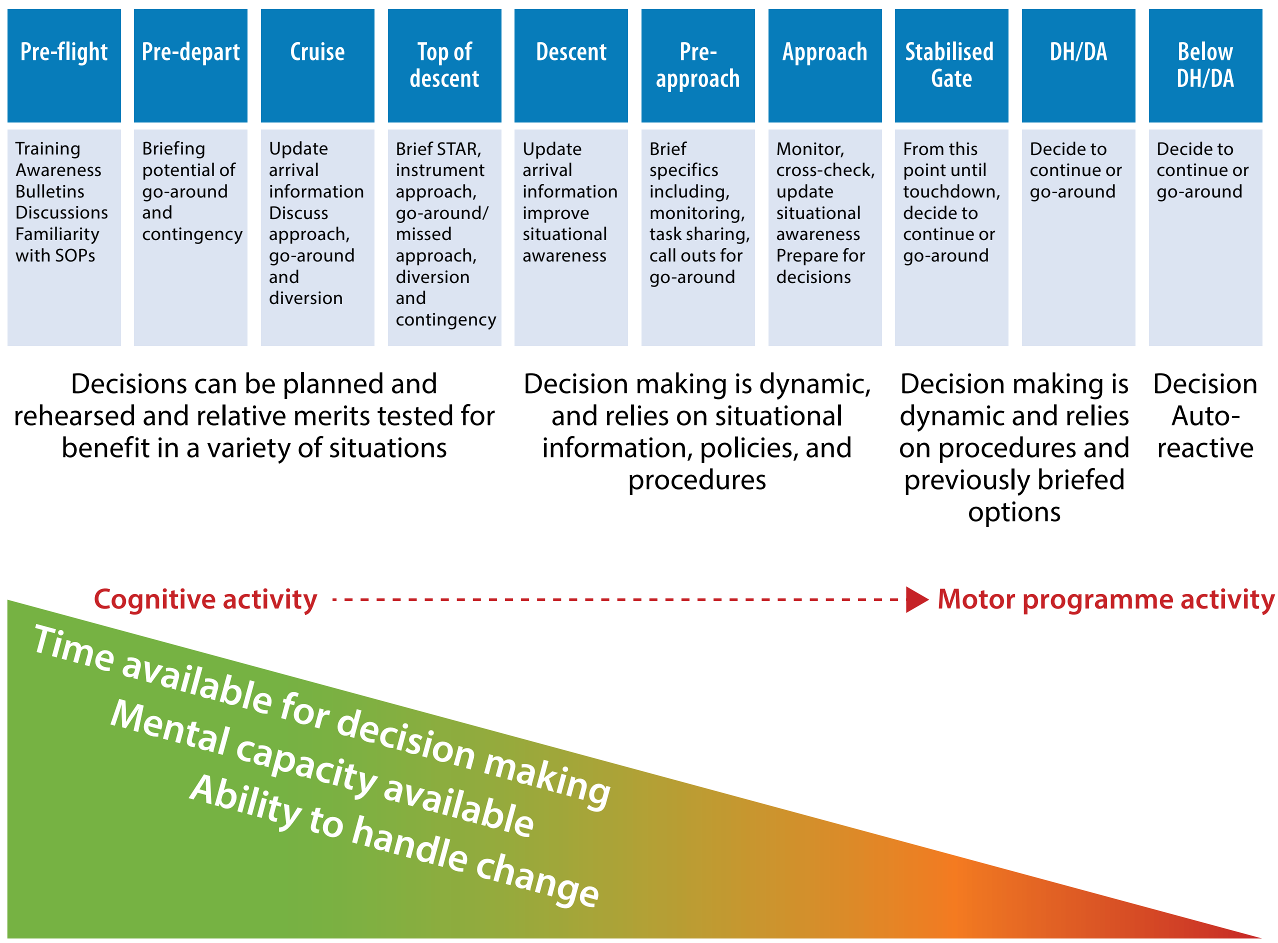
Go-arounds are even of benefit to the ATM system because they may reveal system and procedure design deficiencies such as hot and high approach vectoring, excessively tight spacing or inappropriate approach design. Possible separation issues arising due to go-arounds (e.g., during simultaneous landing and departure operation or during unsegregated parallel runway operation) will reveal where the ATM system is working at or above its safe capacity limits. They can even be anticipated and their risks mitigated in advance.

While the go-around manoeuvre is not hazardous in itself, it becomes hazardous when executed improperly (IATA, 2016). As this applies to other flight manoeuvres like takeoff, approach or landing as well, it is obvious that go-arounds need the same attention and focus in terms of pilot training. Therefore, go-around training should not only include training in the technical competencies required by a pilot to perform the go-around manoeuvre correctly but should also incorporate training in non-technical competencies associated with the go-around manoeuvre like situational awareness, communication and decision-making.

Flight crews have to be made aware of adverse effects on decision-making and cross-monitoring of several cognitive biases like anchoring bias, attentional tunnelling (tunnel vision), confirmation bias and plan continuation bias. Moreover, disorientation or startle effects may cause human performance to deteriorate further during go-arounds if unexpected aircraft or system behaviour occurs. Expectancy and confirmation biases strongly influence individuals' mental models of their current situation. The first step in countering cognitive biases is to identify them. For example, flight crews might be trained in 'de-biasing' techniques, such as imaging how a planned course of action might fail, before committing to that plan. Critical thinking and a willingness to search for information that is contrary to one's mental model and other methods for de-biasing like mutual cross-monitoring and early challenging/intervention (noticing/alerting/taking over control), pattern matching as well as mental priming for go-around can be lifesaving. The decision-making process associated with go-arounds starts during pre-flight preparation and should be reviewed by the flight crew continuously during the flight as shown in Figure 15.

In a recent safety study, more than 65 percent of the flight crews reported that they had experienced a situation in their career in which neither pilot on the flight deck called for a go-around even though it was required, which might explain why a go-around, although being a normal procedure, is still not a frequent occurrence. Even today, there may still be barriers within the aviation system which prevent flight crews from initiating go-arounds, despite being required to perform one (e.g., individual pilot's risk perception that landing is the safer option, schedule or fuel consumption considerations, authority gradient on the flight deck, non-acceptance of stabilised approach policies, lack of training/go-around proficiency or "get-there-itis"). Get-there-itis or plan continuation bias is a proclivity to continue a planned or habitual course of action past the point when changing conditions require altering the plan. This is the strong unconscious tendency to forge ahead with the original plan in spite of changing conditions. This bias grows stronger near the end of the mission as the crew anticipates landing the aircraft and completing the flight. Plan continuation bias may have the effect of obscuring subtle cues which indicate that original conditions and assumptions have changed. In addition, 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.

Figure 15. **The decision-making process associated with go-arounds**



This is why the role of the PM and other qualified crew members on the flight deck (supernumerary or enlarged crew) is so important, especially for the prevention of approach and landing accidents such as runway excursions. In contrast to the PF, who may easily become task saturated, especially in manual flight, the PM (and the other crew members on the flight deck, if applicable) may have more mental capacity and thus better situational awareness to detect trends and flight path deviations. If the PM or the other qualified flight crew members are feeling uncomfortable or not confident with the safe outcome of the approach and landing, they should intervene (e.g., by speaking up and finally calling for a go-around, if required). With regard to the prevention of runway excursions in particular, it is important to promote that *any flight crew member may call for a go-around at any time and at any stage during the approach and landing (until the selection of reverse thrust), unless abnormal or emergency situations dictate otherwise*. There should be consensus in the industry that at least the following apply to go-arounds in normal operation:

- A go-around must be performed as soon as any flight crew member calls for it, irrespective of the caller's rank or experience;
- Go-around execution should neither be delayed nor discussed; the go-around should be applied without hesitation;
- A go-around can be initiated at any time during approach and landing until the selection of reverse thrust;
- Once initiated, a go-around must be completed; and,
- A pilot should never have to justify a go-around decision.

The philosophy that either pilot can call for a go-around is vital and should be an important item in aircraft operators' role descriptions and flight crews' initial and recurrent trainings. Status hierarchy and status generalisation effects (e.g., attributing a general low status to copilots or thinking that a pilot without a PIC rating is a less competent pilot than a pilot with a PIC rating) might still be present in today's aviation and act as a barrier to effective and safe team decision-making. Aircraft operators' culture, policies, SOPs and training should ensure that it is not more difficult for a less experienced copilot to call for a go-around than for an experienced commander, and that both pilots are equally open to accepting intervention from each other when working together. Indeed, especially the cockpit role of the PM is more that of a supervisor for the PF than of an assistant, irrespective of rank or experience of the pilot fulfilling this role.

What can aircraft operators do to implement the recommendation?

Aircraft operators should have a go-around policy which is separate from other policies such as their stable approach policy. The first reason for this is that go-arounds might be necessary for various reasons besides an unstable approach. The second reason is that the go-around decision is one of the most important decisions for the prevention of runway excursions and requires clear and unambiguous SOPs, guidance and training. The policy underlying these SOPs, guidance and training should therefore be comprehensive. The following should be considered when establishing the policy, SOPs and training practices:

- Aircraft operators' go-around policy should define the go-around as a normal procedure which should, as soon as the need is identified by any of the flight crew members, neither be delayed nor discussed, and which should be applied without hesitation. Once the go-around decision has been initiated, it must be completed.
- Aircraft operators' SOPs should not contain any restrictions for the PM and/or the SIC(s) to call for a go-around at any time during approach and landing, until the selection of reverse thrust. This should not affect the emergency authority of the PIC. The role descriptions for the PM and for the copilot roles (e.g., second/first/senior first officer) should contain a formulation providing unrestricted authority for mandating go-arounds. Overruling a SIC's go-around call by the PIC should only be allowed in the event of previously briefed abnormal situations or (impending) emergencies. The definitions and regulations for supernumerary and enlarged flight crew members should also specify the means by which they can intervene effectively, if required, depending on their qualification and possibilities on the type-specific flight deck.
- Aircraft operators' go-around policy should explicitly express the senior management's commitment that flight crews are always free in their decision to go around and divert without having to justify the decision, even if this leads to operational impacts such as delay, missing night curfews, additional fuel consumption, diversion, etc. Instead, go-arounds should be promoted and rewarded by management in order to encourage the ethos of go-around as a safety manoeuvre. The operator's fuel policy should ensure that flight crews have the freedom to uplift sufficient extra fuel if they foresee that a go-around may be needed at the destination or destination alternate. Nevertheless, the go-around compliance rate should be monitored by safety management. Aircraft operators should consider, based on the maturity of their safety culture, whether flight crews should generally report go-arounds or reasons for them, according to whether this would have an inhibiting effect on flight crews' go-around decision-making.
- Aircraft operators' go-around policy should require their flight crews to always be *go-around-prepared* and *go-around-minded*. In order to always be sufficiently prepared for a go-around and to cope with complex missed approach procedures or demanding environmental conditions (e.g., weather, terrain and traffic), which can easily result in high workload, mental overload and task saturation, especially if the flight crew's mental capacity has already been reduced (e.g., by fatigue, distraction or lack of proficiency), the following should be considered when determining the policy and SOPs associated with go-arounds:

- The go-around policy should contain a list of possible scenarios which may mandate flight crews to discontinue or go around from an approach or a landing (until the selection of reverse thrust) and include, at least, the following:
  - Go around, if the visibility or ceiling is below the minimum required for the type of approach at the specified gates (e.g., outer marker, 1,000′ AAL or minimum);
  - Go around, if the appropriate visual references are not obtained or are lost at or below MDA (or minimum descent height)/DA (or decision height) by either pilot. This includes the flare and touchdown;
  - Go around, if prior to touchdown the wind is above the operational or pre-determined wind limit or the runway status is below the limit determined by the flight crew's landing performance assessment;
  - Go around, if the criteria for a stable approach are not met at the relevant approach gate(s) or can no longer be maintained until touchdown;
  - Go around, if technical defects or failures occur during approach which might inhibit a safe continuation of approach, landing or go-around;
  - Go around, if doubts by either pilot exist about the aircraft's geographic or spatial position;
  - Go around, if confusion by either pilot exists about the use or behaviour of the automation;
  - Go around, if it is foreseeable that the go-around routing and path will not be sufficiently clear of adverse weather or restricting traffic;
  - Go around, if instructed to do so by ATC;
  - Go around, if required by type-specific reasons as outlined in the respective FCOM; and,
  - Go around, if required by special considerations associated with CATII/III operation.
- Flight crews should be required to check in advance the missed approach in the FMC to match the published or expected missed approach procedure on the approach chart for the approach to be flown.
- Flight crews should be required to include an assessment of the expected fuel status at go-around initiation, the expected threats during the go-around (e.g., expected weather and winds on the go-around route, effects of aircraft weight, complexity of the missed approach procedure, go-around proficiency and experience, traffic in the missed approach area) and the remaining options after the go-around in their approach briefing, highlighting in particular circumstances that might require them to adapt the go-around procedure (e.g., to avoid altitude busts or speed exceedances in case of early level offs). If deemed necessary (e.g., for proficiency reasons), the sequence of actions, the task-sharing and callouts can be rehearsed in the approach briefing as well.

- Flight crews should be provided with guidance on how to proceed after two consecutive approaches to the same runway at one airport and on the requirements for an exceptional third attempt or the necessity for a diversion.
- Flight crews must acquire the visual reference at the latest at the minima and maintain it until landing. If at any time after passing the minima, one of the flight crew members loses sight of the required visual references or is not sure about the safe outcome of the landing, a go-around must be initiated or called for. It should be highlighted that this option remains available until the aeroplane touches the ground and up to the selection of reverse thrust.
- Aircraft operators should consider using a concept flight crew's role assignment and task-sharing supporting stable approaches and smooth and coordinated go-arounds (e.g., as promoted by the PICMA[13] approach and go-around concept or the one-team-cockpit concept).[14]
- When operating into special/challenging airports (e.g., CAT C airports) or airports with specific restrictions (e.g., PIC landings only), aircraft operators should consider requiring special monitoring and intervention training for SIC/copilots operating those flights, in order to guarantee qualified and effective monitoring of such approaches and landings in all cases.
- Aircraft operators' flight crew training should consider that flight crews are traditionally trained to perform a go-around at the approach minima. However, most go-arounds do not happen at the approach minima. It is thus important that the training and checking in the simulator includes different go-around scenarios, both prepared and unprepared, during different stages of the approach, including go-arounds during flare and touchdown (before activation of the thrust reversers). While conducting the go-around, adherence to the defined PF/PM task sharing and the optimum use of crew resource management (e.g., for monitoring flight parameters and calling any excessive flight parameter deviations or any change in expected conditions) are of paramount importance and should be a focus in the training. Nevertheless, flight crew training should also incorporate intervention training on how the PM can take over control from the PF, if required, in order to perform the go-around. For such cases, the SOP should require the PM to call out all go-around-related memory items once actioned and include the required PM action if a required memory call involved in initiating a go-around has not been made at the appropriate time by the previous PF.

[13] PICMA – PIC monitored approach; see www.picma.info
[14] One-team-cockpit-concept, see Schmidt,T. A.; Nixon, J.; Kourdali, H. K.; Kemény,C.; and Popp, C. "*OneTeamCockpit — Enhancing the Flexibility of Flight Deck Procedures during the Go-around.*"

- Aircraft operators should establish internal go-around compliance rate measures, targets and goals (safety performance indicators and targets (SPI and SPT). Where necessary, flight crew associations and operator management should establish a basis and/ or process in which FDM can be used to assist in effectively managing go-around compliance targets. Depending on the actual number of go-arounds in the operation and thereby on the availability of sufficient data to analyse, it could be helpful to investigate every go-around in order to check the correct implementation of go-around procedures. Regular feedback on the results of such analytics should be presented to the pilot workforce and accountable safety boards/committees.

4.7 Where and how should flight crews touchdown? (OPS 21, 22)

Recommendation OPS 21: Aircraft operators should clearly define their policy for a safe landing and publish it in their SOPs and operations manuals. This policy should clearly define acceptable touchdown limits and prohibit intentional long and short landings, e.g. to minimise runway occupancy or minimise taxi time to the gate. The supplementing SOPs and guidance should include means, methods and responsibilities with regard to how a crew will identify and act on such limits. Appropriate classroom and simulator training should be provided.

Recommendation OPS 22: Aircraft operators should publish SOPs and guidance for landing techniques that are aligned with the ICAO Global Reporting Format and manufacturer's guidance for all runway states and environmental conditions. Aircraft operators should require their flight crews to always favour a go-around or diversion rather than to attempt a landing when approaching wet, slippery/contaminated runways without appropriate stopping margin and/or in limiting wind situations. Appropriate training should be provided including training in the ICAO Global Reporting Format.

Why should aircraft operators follow this recommendation?

Landing excursions are of two types: overruns, in which aircraft run off the end of the runway surface, and veer-offs, in which aircraft exit the side of the runway surface. Findings of the FSF Go-Around Decision-Making and Execution Project (2017) show that collective situational awareness is low during the landing phase. Although most operators have policies defining where the touchdown should occur, very few have guidance or SOPs explaining how to determine where the touchdown should occur, or how and when to determine whether a go-around should be executed. For example, most operators specify that the aircraft should touch down in the touchdown zone (TDZ), on the centreline; however, they do not train or specify how to determine if the aircraft has passed the TDZ, who should make the determination, or how much of a deviation from the runway centreline is permissible before a go-around should be conducted. Most flight crews say either a gut feeling or experience helps them to judge when an aircraft has passed the acceptable limit, even though they readily state that their experience does not include go-arounds from the landing phase. The impact of improving collective situational awareness in the landing phase could be significant.

The landing phase is complex and therefore does not leave crews many opportunities to make complex instantaneous calculations. 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 that there is the greatest amount of distance remaining to absorb factors the pilot does not have control over, such as unreported tail wind, late wind shifts from crosswind to tail wind, worse-than-expected runway friction capability, etc. While still in IMC conditions, flight crews are expected to follow the localiser and glide slope or equivalent indications for their approach. During an ILS approach, it would be best to continue exactly on the localiser and glideslope, like during an autoland, even in VMC. However, signal bending or disruptions (e.g., due to departing aircraft, or the lack of exact electronic guidance to the touchdown point during non-precision approaches) require the PF, when transitioning to VMC conditions, to gradually shift his/her attention to the visual approach indicator or to the runway and the touchdown point while still using the instruments as a backup. Once stabilised on the profile and if the runway is in sight, flight crews can already project 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, 300 m from the runway threshold. This technique ensures that the landing complies with the assumptions made by the performance calculations: stabilised 3-degree profile, appropriate threshold crossing height (TCH, usually calculated with 50 ft) and flying at no more than the approach speed which was used for the calculation. The position of the runway and the touchdown point on the windshield are 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.

However, visual illusions may result in difficulties for flight crews to judge the correct position of the aircraft on final approach when the runway is in sight. A non-standard runway, and different terrain and weather perceptions than flight crews

Table 3.

Visual illusion of being too HIGH on approach → may lead the PF to increase descent → higher risk of short/hard landings	Visual illusion of being too LOW on approach → may lead the PF to reduce descent → higher risk of long landings	Visual illusion of being too FAR AWAY from the runway → may lead the PF to reduce descent → higher risk of long landings
Long(er) runway than used to;	Wide(er) runway than used to;	Low intensity ALS/RLS; and,
Narrow(er) runway than used to;	Short(er) runway than used to; and,	Flying in haze.
Bright illuminated ALS/RLS;	Downslope of runway/terrain	
Upslope of runway/terrain;		
Entering MIFG (shallow fog); and,		
FG/BR, RA, DU (fog/mist, rain, widespread).		

are used to may create visual illusions which may increase the risk of missing the optimum touchdown point, thus increasing the risk of runway excursions, if not accounted for by the flight crew. Table 3 provides a list of typical visual/optical illusions and their effect on runway sight and profile management.

Additionally, visual aim point versus gear touchdown point differences increase as the 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.

If installed at the runway, a PAPI may aid the flight crew by providing visual descent guidance information during the approach (Remark: According to ICAO Annex 14, Part 5, dated 1.1.2020, the operation of T/AT-VASIS should be discontinued). The PAPI on-slope signal should usually coincide with that of the ILS to provide guidance down to flare initiation. However, even this aid does not come without restrictions. Flight crews may have to deal with differences between the angle of the approach glide path and the angle of PAPI guidance, or the PAPI may be calibrated for a certain eye-to-aerial height leading to deviation indication (e.g., one white – three red) on the PAPI although flying exactly on the ILS glide if not using the largest type of aircraft regularly approaching the runway. Although "one white – three red" should clear all obstacles in the approach by a safe margin, this margin may provide a wheel clearance of as low as 1.5 m, depending on the installations made by the airport. Therefore, diving below the nominal PAPI glideslope in order to shorten the touchdown, as often used on short runways or those with displaced thresholds, is not advisable. Additionally, effects by condensation, snow, ice, dirt or bad illumination may impair the use of this generally useful support system for flight crews. Additional risk factors for floating into the runway like tail wind components, excess airspeed above the threshold, aircraft-specific ground effects or extended flares because of crosswinds may increase the likelihood of not touching down in the touchdown zone.

In general, touchdown zones vary in length, with a determining factor being the total runway length. Runways of 7,990 ft and longer have touchdown zones of 3,000 ft long (FAA), and runways of 2,400 m and longer have touchdown zones of 900 m long (ICAO). Relative positioning markings are present within the TDZ and are clearly identifiable on a non-contaminated runway. The aiming point is the widest marking located at a distance of 1,000 ft from the threshold (FAA), and 400 m from the threshold (ICAO[15]), with the end of the TDZ being identified by the last marking at 3,000 ft (FAA) and 900 m (ICAO) on runways greater than 7,990 ft or 2400 m. Aiming point markings are 150-ft-long white rectangular stripes, one on each side of the runway centreline, which begin at the distances indicated below. The width of the aim point markings varies according to the width of the runway. ICAO also defines touchdown aim points in reference to the available landing area in Table 4.

Approach alerting and monitoring systems such as SmartLanding provide aural alerts when an aircraft has passed a company-defined touchdown area. When an aircraft passes this area without touching down, an aural alert such as 'long landing, long landing' is given (Honeywell International, 2019). SOPs may then dictate a go-around. This objective warning immediately enhances crew awareness and leads to better decision-making. In the absence of such a system, the PM, through SOPs, can be directed to monitor the passing of the touchdown limit and make an active call such as 'TL' [touchdown limit], 'deep landing' or 'end of zone' after passing the last marking indicating the passage of the TDZ. In cases in which the runway is contaminated and markings are not visible, a couple

Table 4.

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

[15] This may vary based on factors affecting visual approach slope obstacle clearance and PAPI positioning

of options exist. If available, runway remaining markers or apparent geographic references (e.g., crossing taxiway/runway) can be used, or, using the landing distance 'rule of thumb', flight crews can calculate that for an aircraft traveling 250 ft/76 m per second, the normal touchdown area of 1,000 to 2,000 ft (300 to 600 m) will be passed within four to eight seconds — 250 fps x 4–8 seconds = 1,000 to 2,000 ft. Calculations also will show that the end of the 3,000-ft-long TDZ will pass within approximately 12 seconds — 3,000 ft/250 fps = 12 seconds.

Most operators specify that the touchdown should occur on the runway centreline, but do not say how this should happen or who determines when the aircraft is drifting. As important as it is to have situational awareness regarding a longitudinal limit, it is equally important to understand lateral limits. Manufacturers often provide cockpit visual cues and techniques for determining where the main landing gear is in relation to the aircraft centreline. As an example, Boeing says that for the 787, the view through 'the lower outboard corner of the pilot's forward window to the ground is a good visual reference for the outboard side of the main landing gear wheels on the same side. The lower inboard corner of the pilot's forward window is also a good reference for the opposite side main gear wheels' (The Boeing Company, 2013). In the absence of other lateral limits, maintaining the most outboard main landing gears on either side of the centreline (straddling) is a reasonable limit. Using visual cues, as in the example above, can help determine the positioning of the main landing gear. This is considered a rough operational guideline with its own limitations; however, there are no known alternatives other than relying on 'gut sense'. The monitoring of this positioning can be performed by the PM during the landing, and if he/she sees that the position of the aircraft is incorrect, he/she can make an appropriate call: 'Drift limit.' In this case, SOPs would dictate a go-around.

What can aircraft operators do to implement the recommendation?

In order to support their flight crews in preventing runway overruns and veer offs, aircraft operators can publish safe landing and touchdown policies and SOPs and provide appropriate training. At least the following should be considered when establishing the associated policies, SOPs and training practices:

- Aircraft operators should establish safe landing guidelines for their flight crews which should consider at least the following:
  - Fly a stabilised approach down to the runway.
  - Height at threshold crossing should be 50 ft (otherwise landing performance may not be achieved).
  - Speed at threshold crossing should be in accordance with manufacturer's guidance. Bleeding off additional airspeed by wind/gust increments, added as per guidance, should be started accordingly.)
  - Tailwind for a non-contaminated runway is generally no more than 10 kts, or less if landing performance or the flight crew requires lower operational limits, and no more than 0 kts for a contaminated runway.
  - Touch down just beyond the touchdown aim point following a normal flare, and not beyond the touch down limit (typically the end of the TDZ). If not touched down within the TDZ (or revised touchdown point limit), go around.
  - Touch down on the runway centreline with the main landing gear on both sides of (straddling) the runway centreline. If all main landing gear are on one side of the centreline, go around.
  - After touchdown, promptly transition to the desired deceleration configuration: brakes, spoilers/speed brakes and thrust reversers or equivalent (e.g., lift dump). ***Note***: *Once thrust reversers have been activated, a go-around is no longer an option.*
  - Monitor both aircraft speed and runway distance remaining during landing roll. (Aircraft operators should direct specific actions for the PF and PM at appropriate distances — 900m, 600m, 300m remaining — in case speed is higher than normally expected).
- Aircraft operators should prohibit intentional short or long (deep) landings (e.g., to minimise runway occupancy time for ATC reasons or to minimise taxi time to the gate for economic or schedule considerations). Flight crews should be required to always land within a runway's touchdown zone or within the revised touchdown point limit (e.g., in case the TDZ of a runway cannot fully be used due to critical landing performance).
- Aircraft operators should define procedures describing how flight crews can jointly determine a revised touchdown point limit (TPL; e.g,. during approach briefing). A revised touchdown point can be determined by citing a known distance point along the runway (e.g., taxiway marking, runway distance marker or time period from the time the aircraft crosses the threshold — one second approximates 250 ft (76 m) in distance.)
- Aircraft operators should establish callouts to be used during landing which alert the PF to the fact that the touchdown point limit or the lateral drift limit has been reached (e.g., PM: 'End of zone' and/or 'Drift limit'. Both callouts require an immediate go-around. If the PF does not comply with the go-around command, the PM shall take over control in order to perform the go-around.
- Aircraft operators' training should make their flight crews aware of the different existing touchdown zone markings and different runway layouts during their initial and recurrent training. They should also emphasise the importance of good practice on all runways, long and short, to provide a standard flare and landing technique. This training, as well as airport briefings, should include special or unusual operational requirements at specific airports in the company's network (e.g., downdrafts/updrafts due to terrain, shifting winds, and visual illusion induced by narrow/wide runway or night operations). Training on the use of the head-up guidance system, if installed, should

be conducted during ground courses to ensure landing within the appropriate touchdown zone, with practical training conducted during simulator sessions.

- Aircraft operators should provide SOPs and training for their flight crews, supporting them with the correct touchdown techniques. These SOPs must follow corresponding FCOM/FCTM content unless the case for alternatives or amplification is formally documented for reference and explicit post holder approval has been given. Clear SOPs are required for all runway braking action circumstances which may be encountered. Operation manuals should cover interpretation of all runway surface condition reporting methods likely to be encountered (GRF and others) and the use of 'pilot reports' in any format likely to be encountered should be subject to an SOP as well.

4.8 Bounced landing recovery (OPS 25)

Recommendation OPS 25: Aircraft operators should define policies and procedures to address bounced landings. Whenever available, aircraft operators should take into account and include manufacturers' guidance. Moreover, aircraft-specific and appropriate training, including simulator training, should be provided for flight crews.

Why should aircraft operators follow this recommendation?

A bounced landing is when an aircraft touches down and becomes airborne again. This may easily contribute to a runway excursion event because the remaining runway for another touchdown, pilot's sight or the aircraft's controllability may become limited. Bouncing at landing is usually 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; and,
- Lack of pilot proficiency or training of manual flying skills.

Most threats which may lead to possible bouncing can be anticipated and identified well before starting the approach and landing, and should be considered in flight crew's TEM briefing (e.g., special wind effects due to orography or weather, training flights, high temperature/low density overhead the TDZ, non-ILS/RNP approaches, especially with steep PAPI or approach glide path). These considerations could also be taken into account during pre-flight preparation when considering extra fuel for possible go-arounds.

When a bounced landing occurs, flight crews have different options, depending on the aircraft manufacturer's and aircraft operator's guidance and SOPs. As there may be different intensities of bounced landings, manufacturers and aircraft operators might differentiate their recovery techniques between 'light' (<1.5 m/5 ft) and 'high' bounces (>1.5 m/5 ft)*. In general, the most effective method to safely recover from a bounced landing is to initiate a go-around while considering the aircraft's body angle and closure to the surface in order to avoid a tail strike and controllability issues. (Sometimes this manoeuvre of initiating a go-around after a touchdown is called 'rejected landing' which must not be confused with the actions needed during a takeoff reject, like retarding the throttles.)

What can aircraft operators do to implement the recommendation?

In order to support their flight crews in dealing with bounced landings safely, aircraft operators should provide good SOPs and training. The following should be considered when establishing such SOPs and training practices.

- Aircraft operators should make sure that their SOPs include techniques for bounce recovery which are aligned with aircraft manufacturers' guidance or have been established in coordination with the manufacturer of the aircraft used. When operating mixed fleets, their documentation and training should clearly show differences in bounce recovery between aircraft types.
- Bounced landing recovery training should be included in initial and recurrent training, including various scenarios with light and high bounces. This training should highlight that safe go-around initiation and execution are the priority, rather than trying to land, especially from a high bounce. It should also include scenarios requiring the PM to actively monitor and intervene in mismanaged recoveries, including taking over control in order to go around safely. Emphasis should be placed on the correct reaction of the PF to hand over controls and instantly switch to the PM role without negative feelings.
- The SOP and training should make clear that in all cases, a go-around after touchdown (rejected landing) can still be initiated until the selection of reverse thrust. However, once a rejected landing is initiated, the flight crew must be committed to proceeding and not retard the thrust levers in an ultimate decision to complete the landing. Runway excursions, impact with obstructions and major aircraft damage are often the consequence of reversing an already initiated rejected landing.
- Training flights require special considerations. Training for the instructors should focus on bounce prevention during training flights (e.g., anticipating threats which could lead to bounced landings and incorporating this into their TEM briefings with the trainee). There should be no difference in bounce recovery techniques and training for line flight crews and instructors in order to ensure that a common philosophy is practiced during flight operation. Instructors should strive to show role model behaviour (i.e., favouring a go-around rather than trying to land, especially from a high bounce. In order to detect possible areas

for improvement in the training system, aircraft operators should consider using FDM to detect negative trends within training and line operation.

Different recovery techniques

In the event of a light bounce, a typical technique for recovery 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 reverse thrust.

In the event 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 of a tail strike or second touchdown has disappeared. Then the normal go-around technique can be used.

4.9 Change of controls during landing and taxi-in (OPS 26)

Why should aircraft operators follow this recommendation?

Recommendation OPS 26: Aircraft operators should develop guidance on whether and when a change of control during landing rollout has to take place and require their flight crews to brief and agree on the planned runway exit, taking into account the friction status of both runway and runway exit, whenever available. When a change of control is necessary during rollout, this should be performed below taxi speed and when the aircraft trajectory is stable.

Still today, many companies and some aircraft designs do not allow the second-in-command (SIC)/copilot to taxi the airplane. Consequently, when the SIC is PF, control must be transferred at some point. This situation presents a great deal of potential for the two crew members to have different perceptions or expectations about which exit to take, when to take over and in which aircraft configuration. Resulting inappropriate braking or high taxi speeds during or before turning off the runway may lead to runway and taxiway excursions.

Remark: The need for change of control during a landing roll, which continues to cause lateral runway excursions, can be reduced and eventually eliminated either by the buyers of new aircraft not selecting the cost-saving option of a left side only steering tiller or (preferably) by aircraft manufacturers ceasing to offer this option altogether.

What can aircraft operators do to implement the recommendation?

Aircraft operators should provide flight crews with SOPs that allow continuous deceleration upon landing, a safe changeover of controls and a safe taxi-in. The following should be considered when establishing such SOPs and associated training practices:

- A safe landing and taxi-out starts during the approach briefing. Aircraft operators' SOPs should therefore require the flight crew to agree on the optimum runway exit and possible alternatives based on their landing performance calculations. The more defensive/conservative (i.e., risk averse) option as preferred by either pilot should always be chosen by the flight crew, irrespective of efficiency considerations (e.g., taxi time, break wear or ATC requirements). In their TEM briefing and resulting autobrake selection, flight crews should consider not only the runway status but also the taxiway status in terms of contamination and slipperiness (especially during wet and winter operation), provided such information is available or can be estimated.
- Aircraft operators should consider providing flight crews with limitations and guidelines for maximum taxi speeds when turning off the runway, depending on the kind of taxiway used (e.g., high-speed or 90-degree turnoffs) highlighting the influences of different runway/taxi surfacing (e.g., grooved or not, de-iced or not, rubber debris, etc.).
- If using a single tiller aircraft type, aircraft operators should consider retrofitting a right seat tiller, or, if they are in the process of purchasing new aircraft, ordering a configuration including tillers for both pilot seats. In the event that a retrofit is not possible, an explicit SOP for changeover must be provided for flight crews considering rudder pedal steering angles and rudder effectiveness at low speeds. Transfer of aircraft control during the landing rollout should be reviewed as part of the approach briefing. Ideally, the handover of controls, if required, should be accomplished after decelerating into the low speed regime, prior to vacating the runway, even if this leads to passing a planned exit. The control change should normally be initiated by the PF (e.g., by the call 'You have control'. If the rate of deceleration is not appropriate for the runway distance remaining, the PM should take control of the aircraft and apply maximum deceleration devices.
- In order to ensure safe team decision-making with regard to runway excursion prevention, it is useful to train and allow SICs to taxi the airplane as well. A taxi-trained pilot will be able to better assess effects of different runway and taxiway friction levels, be more confident in assessing delayed or slowed breaking during landing roll (e.g., on slippery/contaminated runways) and will be a more effective back-up in the event of incapacitation events. Furthermore, it might be a positive investment in safety to stop using aircraft with only one tiller. In any case, copilots should be trained to slow the airplane safely until below taxi speed, including taxiing safely into runway high-speed turnoffs.

5 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: Approach and Landing Accident Reduction (ALAR) tool kit

Flight Safety Foundation: Go-Around Decision-Making and Execution (GADM&E) Project Report

EUROCONTROL: A study of runway excursion from a European perspective

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

J. O'Callaghan. Slippery When Wet: The Case for More Conservative Wet Runway Braking Coefficient Models, National Transportation Safety Board, AIAA AVIATION Forum, 2016.

APPENDIX D
GUIDANCE AND EXPLANATORY MATERIAL FOR AIRCRAFT MANUFACTURERS

Recommendation MAN1: Aircraft manufacturers should present takeoff and landing performance information for dispatch and time-of-arrival for the full range of reportable runway conditions, using common and shared terminology and to agreed standards, set out in FAA ACs 25-31 and 25-32.

Significant progress and agreement as to terminology and standards was accomplished during the work of the U.S. Federal Aviation Administration (FAA) Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC) activity that occurred in 2008 and 2009. In this activity, six of the major manufacturers worked with the FAA, aircraft operators, business jet operators, airport operators and other industry interest groups to recommend a standard terminology for reporting and evaluating runway conditions and criteria for manufacturers to use when computing the aeroplane's performance information for takeoff and landing.

TALPA ARC recommendations pertaining to aircraft performance data for non-dry runways have been issued by the FAA in two Advisory Circulars, AC 25-31 for takeoff and AC 25-32 for landing, as rulemaking activities were not possible at the time. This allows flexibility for manufacturers regarding whether or how to implement this new performance information. Some manufacturers have created operational data using terminology and standards consistent with the TALPA ARC recommendations.

In parallel and as part of the overall implementation of the TALPA recommendations, the International Civil Aviation Organization (ICAO) has developed Document 10064 "Aeroplane Performance Manual" to combine guidelines on certification and operational requirements regarding aeroplane performance. It was developed in the context of the Friction Task Force of the Aerodrome Operations and Services Working Group on the basis of existing and proposed national regulations and the TALPA ARC proposals. This new harmonisation of the runway surface condition assessment and reporting throughout the world is named Global Reporting Format (GRF).

To translate the ICAO standards into European regulation, the European Union Aviation Safety Agency (EASA) launched Rulemaking Task RMT.0296, which resulted in the publication in 2016 of NPA (Notice for Proposed Amendment) 2016-11, proposing appropriate amendments to the operational regulation, revised airworthiness standards for takeoff performance on contaminated runways and new in-flight landing performance computation at time of arrival. The proposed changes are expected to increase the current level of safety in relation to aeroplane performance, to improve harmonisation with FAA rules and to ensure alignment with ICAO Opinion 02/2019 containing the proposed new EASA regulation adopted by the European Commission.

In 2019, FAA tasked the Aviation Rulemaking Advisory Committee (ARAC) with a review on implementing TALPA ARC recommendations as a new airworthiness standard instead of advisory material, in order to incentivise manufacturers to implement this new performance information. This proposal is currently being discussed by the FAA Flight Test Harmonization Working Group (FTHWG).

Those new physics-based time-of-arrival assumptions complement the existing landing distances assumptions at time of dispatch, which are not harmonized among all runway states. A proposal to harmonise landing distance assumptions at time of dispatch on all runway states is also being discussed in the context of the FAA FTHWG.

It is recommended that all certification agencies keep working to ensure that takeoff and landing performance information are proposed in similar standards.

In the meantime, for existing designs, the data provided by manufacturers should allow flight crew to determine takeoff and landing performance for any runway surface condition as reportable via a runway condition report (RCR) standardized by ICAO Annex 15. The use of standard terminology facilitates the mapping of the data to the reported condition.

While the standards for deriving the performance data are not retroactive, it should be ensured that a minimum compliance with the above mentioned ACs is established, in particular for the landing distances at time of arrival (LDTA), there should be:

- Data available for all six reportable braking action categories;
- Accountability for temperature and runway slope; and,
- Accountability for recommended approach speeds.

It is recognised that it may not be reasonably achievable to produce updated performance data. European operational regulation sets minimum requirements for the availability of performance data based on the aircraft performance class and the type of operations. Manufacturers should ensure that they meet or exceed these minimum requirements in the data they provide to the operators, and that this data is made available in a timely manner before these new rules come into force on 12 Aug 2021.

Recommendation MAN2: Training material promulgated by aircraft manufacturers and aircraft training providers should emphasise the necessity of making best use of deceleration means, including speed brakes, wheel braking and reverse thrust, in a timely manner, until a safe stop is assured, and in particular when conditions are uncertain or when runways are wet or contaminated by applying full braking devices, including reverse thrust, until a safe stop is assured.

This type of information is often included in the manufacturer's flight crew operating manuals or flight crew training manuals with supplemental information, possibly in bulletins or magazine articles.

An example of a manufacturer's guidance on operating on wet or contaminated runways is provided later in this appendix.

Delayed application of deceleration devices has been contributory in numerous runway excursions (12% per International Air Transport Association [IATA] Safety Trend Evaluation, Analysis Data Exchange System [STEADES] analysis, 2019).

Reference

STEADES Incident and Accident Data 2008Q1 to 2018Q2, International Air Transport Association, 2019.

Recommendation MAN3: On-board real time performance monitoring and alerting systems that will assist the flight crew with the land/go-around decision and alert when more deceleration force is needed during the landing roll should be made widely available.

Contributors to longitudinal runway excursions at landing can occur during both the air phase and ground phase. These include:

- Air phase: Unstable approach, wind shift at low altitude, long flare, long de-rotation. Without actual information on the risk of a consequent runway overrun, the crew may be tempted to continue an approach in the belief that they may recover the situation, or that they have sufficient landing distance margins.
- Ground phase: Late selection of engine thrust reversers, too early cancellation of reverser, runway friction coefficient lower than expected, late or delayed manual braking.

One of the major enhancements recognized for longitudinal excursion prevention is on-board technology to help the pilot to decide to land or go around (air phase), or to provide alerting on the need to apply all deceleration devices to their maximum utilisation during the ground phase. Different systems are currently available or in development to provide the flight crew information to assist with these decisions for which references are provided below. Guidance material can be found in — ED-250, Minimum Operational Performance Standard for a Runway Overrun Awareness and Alerting System.

The European Union agreed in mid-2020 to mandate installation of such functionality, termed ROAAS (Runway Overrun Awareness and Alerting System) for future large aeroplanes, excluding retrofit. In addition to this mandate, manufacturers should consider proposing solutions adapted to retrofit scenarios, when feasible. Manufacturers should also consider implementations that provide protection for all runway conditions as defined by the GRF.

References

Airbus Safety First #08 – July 2009 [*https://safetyfirst.airbus.com/app/themes/mh_newsdesk/documents/archives/the-runway-overrun-prevention-system.pdf*]
and FAST
[*https://www.airbus.com/content/dam/corporate-topics/publications/fast/Airbus-FAST55.pdf*]

Konrad G, et al. Development of a Predictive Runway Overrun Awareness and Alerting System, Aviation Electronics Europe (AEE) Conference & Exhibition, Munich, June 2018.

[*https://embraer.com/global/en/news?slug=1206700-embraers-new-enhanced-phenom-300e-receives-anac-easa-and-faa-approval-achieving-triple-certification*]

Recommendation MAN4: The aviation industry should develop systems and flight crew manuals to help flight crews calculate landing distances easily and reliably in normal and non-normal conditions. Systems should have a method to apply recommended assumptions. All landing distance computing tools available for the aircraft (e.g., flight management system [FMS], electronic flight bag [EFB]) and on-board real time performance monitoring and alerting systems (e.g., ROAAS) should be consistent with the overall harmonized set of data used for landing performance assessment. Whenever consistency between on-board alert-triggering thresholds and landing distance computation methods available to the crew cannot be entirely achieved, means to determine these thresholds for the planned conditions and guidance to the flight crew on a recommended course of action should be provided.

The aviation industry has changed greatly in the past decade as to how the calculation of performance in general, and in landing distances in particular, is done. Landing distance assumptions have become much more complex with the implementation of physics-based time-of-arrival dry, wet and contaminated landing distances (assumptions detailed in FAA AC 25-32 and EASA CS 25.1592) on top of the already existing various landing distances assumptions at time of dispatch (see recommendation *MAN1*). New assumptions for steep approach landings or shortened wet runway landing distance associated with grooved/porous friction course surfaces have also been implemented.

This diversity of landing assumptions can make the overall set of data for landing performance assessment difficult to understand for some operators. And those operators also have to cope with various operational landing factors to be applied according to the type of operations.

From the late 1990s, aircraft communications, addressing and reporting systems (ACARS) sand laptops have started showing up in the cockpit, and on-board avionics capabilities have continuously improved. The information the flight crew obtains from these systems is computed based on crew input such as airport/runway, weather conditions, wind, runway conditions, approach type, etc. These systems replace the need for crew to do multiple hand calculations, flipping through paper charts and adding/subtracting/interpolating in cumbersome tables and charts. Often because of the number of computations required, flight crew relied on quick checks of the numbers or didn't do the appropriate performance checks at all. It is now much easier for the flight crew to get an appropriate answer with less exposure to error. It is also easier for the crew to look at multiple scenarios so they can have a plan in the event they obtain additional information late in the approach that the runway has deteriorated. Manufacturers of these devices and methods are continually searching for better ways to do this, and in this very competitive business there is no doubt that improvement will continue.

The availability of such interactive systems, however, does not excuse aircraft manufacturers and operators from presenting the performance information in an intuitive format that is error-tolerant to use. This becomes even more important when the performance tables are only used very occasionally as a backup to an electronic system.

It is also recommended that aircraft manufacturers provide cross-check capabilities between landing distance computation tools available if those tools are not approved. This cross-check can be done manually through appropriate operational methods or automatically through direct communication links between systems.

In the past decade, on-board real-time performance monitoring and alerting systems (e.g., ROAAS) have also started being implemented in some aircraft to assist flight crew during landing.

It is recommended that aircraft manufacturers make all landing distance computing tools available for the aircraft (FMS, EFB) and on-board real-time performance monitoring and alerting systems consistent with the overall harmonized set of data used for landing performance assessment (see recommendation *MAN1*).

However, on-board monitoring and alerting functions must comply with specific requirements in line with ED-250, which may necessitate the adaptation of landing distance computations to ensure that alerts are always pertinent and systematically triggered early enough for the crew to react. Furthermore, real-time constraints and data availability in the avionics environment may not permit the use of the same performance models, input and runway data as in operational tools (e.g., EFBs). Regulators consider that no approach should be initiated when it can be anticipated that alerts will be triggered because available runway length is not compatible with triggering thresholds. Sufficient margins may exist based on the sole result of the LDTA used by the flight crew in planning the approach. There is thus a need to make available to the pilots the criteria used by the on-board function, or to implement automatic cross-checks of the LDTA data available to the crew against these triggering criteria.

Recommendation MAN5: EFB manufacturers and providers should develop user interfaces for the calculation and data entry of takeoff and landing performance data, designed to minimise the possibility of errors introduced by the pilot.

EFB systems should enable the flight crew to perform an independent determination of takeoff and landing data and to implement, where possible, an automatic cross-check of inputs and to ensure correct insertion of the data in the avionics.

EFB systems should use terminology and presentation of data consistent with aircraft systems and aircraft documentation to the extent practical.

Standard operating procedures should be developed to support a cross-check of performance data by both pilots.

All providers of tools for digital takeoff and landing data determination are encouraged to implement safeguards for erroneous data insertions and cross-checks between various data sources. This is to ensure calculations are performed with correct data inputs and that the results are appropriately inserted in aircraft systems.

Any means should be taken to reduce the risk of input errors. This includes the prevention of data inputs which violate aircraft or operator limitations (e.g., maximum weights, tail wind and crosswind limits in combination with different runway states, configurations required for a certain non-normal situation). Any human factors aspects of the concerned interfaces should be considered, along with how they integrate into the specific cockpit environment in which they are meant to be used.

Standard operating procedures (SOPs) should be defined for data inputs in the calculation tools as well as for the insertion of the results in the avionics. This includes independent calculations followed by cross-checks between the crew members and comparison of values from different sources (e.g., manoeuvring speeds from the EFB and the flight management computer).

If technically possible (e.g., through suitable databases), such gross-error checks between different sources and systems should be performed automatically.

Example guidance material may be found in FAA AC 120-76, "Authorization for Use of Electronic Flight Bags"; EASA AMC 20-25, "Airworthiness and operational consideration for electronic Flight Bags (EFBs)"; and in the work from EUROCAE WG-106, which at the time of publication was in the approval stage with ED-273, "Minimum Operational Performance Standard for Electronic Flight Bag (EFB) Software Applications".

Recommendation MAN6: Manufacturers should monitor and analyse (worldwide) runway excursions involving the aeroplanes they support and share the lessons learned — where feasible.

The reporting and investigation of aircraft accidents and incidents is regulated by ICAO Annex 13. The results of such investigations are sometimes shared publicly. However, due to their much higher rate of occurrence, much more can be learned from precursor events if they are identified as such and acted upon.

Some manufacturers review yearly or bi-yearly the significant accidents and incidents as well as the causal factors and issues highlighted by these events. This can be done at meetings and conferences attended by operators, and in manufacturer publications like bulletins, changes in procedures or other information.

Updates to this recommendation reflect the reality that not all overruns can be investigated. Not all overruns are possibly known, especially less severe ones and/or overruns involving older aircraft models in certain regions of the world. Also there are possibly geo-political or conflict limitations.

Recommendation MAN7: Manufacturers should provide information about effective crosswind landing and takeoff techniques, including in low visibility, when required.

The effectiveness of vision enhancement technologies such as cameras that operate outside the visible light spectrum, and other imaging technologies used in low visibility takeoffs or landings may be affected by strong crosswinds due to the narrow field-of-view that may be available. Loss of this enhanced capability and situational awareness in low visibility conditions may adversely affect the touchdown point, either laterally or longitudinally, and could contribute to a runway excursion.

Recommendation MAN8: Manufacturers should consider a function able to:

- Use aircraft data to compute braking action (i.e., maximum achievable tire-runway friction when braking is friction-limited);
- Display it to the crew to assist pilot's braking action report to air traffic control (PIREP),
- Convey it, just after landing, to airport operators and to the aircraft operator(s).

- An accurate knowledge of the runway condition is key for the validity of landing performance computations, and a clear case can be made for the need to improve pilot awareness of runway surface conditions. However, today, generating accurate, consistent and timely updated runway conditions reports on the aerodrome side, and accurate PIREPs on the pilot side is challenging, and there is a risk of having runway conditions information transmitted by air traffic control (ATC) with a lack of real time and accuracy.
- Methods used to evaluate the runway surface conditions have limitations that illustrate this challenge:
  - Runway contaminant type and depth observations conducted by airport personnel are based on a combination of visual observations and spot-checks. It is a generally difficult task to consolidate what may be differing conditions across the entire width and length of the runway into a succinct runway condition report. In addition, during active precipitation and/or freezing/melting conditions, the validity of the information may become outdated soon after it is issued.
  - Runway friction measurements along certain points on a runway provide a more quantitative approach and are useful for identifying trends in runway surface condition but are not recommended for use in predicting aircraft stopping performance.
  - Braking action reports from pilots:
    - ICAO (Annex 6 Part I 4.4.2.1) mandates pilot reporting of braking action that is worse than previously reported. When receiving the information, ATC is mandated to transmit this information to the airport.
    - However, PIREPs of braking action are highly subjective: It is sometimes difficult for the pilot to identify which portion of the deceleration is coming from the wheel braking effect on the runway and which part is due to other aircraft deceleration contributors (aerodynamic drag forces, reverse thrust) which are not linked to the surface condition. This is especially true with the use of autobrake, often recommended on contaminated runways.

- Thus, this guidance refers to a function, complementary to the above regulatorily defined methods of runway surface condition assessment, able to use aircraft data to compute maximum achievable braking action. This can typically be measured when the aircraft is braking, by determining the component of the overall aircraft deceleration force generated by the brakes. This allows the determination of an observed friction coefficient characteristic that can be compared to a scale (DRY, GOOD, GOOD TO MEDIUM, MEDIUM, MEDIUM TO POOR, POOR) standardized in accordance with the ICAO GRF.
- There are systems currently available or in development to report runway braking action to partnering airports and airlines based on the information measured by the aircraft during landing, for which references are provided below.
- In conjunction with 3.5.3 recommendation: Knowing the accurate runway state, together with the possibility to configure (at least manually) this state in the ROAAS alerting settings, will allow for a more timely and accurate ROAAS alerting when runway conditions are degraded.

Guidance material available: ASTM E17.26 workgroup has been launched to produce a standard for the aircraft braking action report generating system, which should then feed the EUROCAE WG-109 standard covering airport runway weather information system, using the data of such a function as an input.

It should also be noted that development of such solutions will depend on multiple factors, including the avionics architecture of a specific aircraft. Not all aircraft will necessarily be able to support this function.

Reference

Airbus Safety First [*https://safetyfirst.airbus.com/using-aircraft-as-a-sensor-on-contaminated-runways/*]

Recommendation MAN9: Manufacturers should consider making available flight deck functionality enabling an accuracy of the 3D aircraft trajectory with regards to the runway (including the touchdown point), especially for degraded visibility landings.

For example, in order to satisfy this recommendation, manufacturers could consider making available:

- Expanded automatic landing capabilities; or,
- Functions that provide additional information to the flight crew to improve positional awareness of the aircraft relative to the landing runway.

An accurate 3D trajectory, including an accurate touchdown point, is desirable, and different solutions can be used to achieve it (e.g., expanded automatic landing capabilities) or as an aid to better reach this objective (e.g., functions that provide additional flight crew information to improve positional awareness of the aircraft relative to the landing runway).

Other solutions not discussed here may be permissible as well. The intent here is not to support means to lower landing minima.

It is to be highlighted that intrinsic differences between large aircraft and bizjets exist (inertia, distance between the centre of gravity and the cockpit, etc.) which may lead to very different considerations in terms of solutions to be developed to address this intended function.

Guidance on expanded automatic landing solutions

Some aircraft types include auto flight guidance system functions that allow automatic landing in low visibility conditions typically designed for CAT 3 operations. For these challenging operations, usage of the auto flight guidance system is mandatory. This system has to demonstrate adequate performance in a wide range of operational conditions (e.g., aircraft weight, airport altitude, wind) regardless of the visibility conditions. Today, this system is rarely used outside the intended original use (CAT 3 operations) mainly because it is dependent on ground instrument landing system (ILS) navigation technology that is known to be sensitive to traffic around the antennas. New navigation means are now available (for example, global navigation satellite systems) and some aircraft manufacturers have certified autoland capacities based on these navigation means. Modern systems may include means to detect and/or compensate known navigation means anomalies (e.g., ILS), in addition to crew monitoring that can generally detect these behaviours.

When landings are performed in degraded visibility conditions (better than CAT 2/3 minima) the usage of an automatic landing system will support the flare manoeuvre and guidance during roll out and ensure appropriate management of the aircraft lateral trajectory prior to or after touchdown. Being in the position to monitor the aircraft trajectory, the crew is supported in their tasks. In addition, for a crew trained for CAT 2/3 operation, usage of the automatic landing system outside of the CAT 2/3 operation should not require additional training.

Therefore development of extended automatic landing system capabilities, that can be used in degraded visibilities condition, in particular when CAT2 or CAT 3 operations are not required or not available (typically CAT2 or 3 runway operated in CAT 1 or better conditions, or CAT 2 or 3 runway with degraded light configuration, or CAT 1 runways), is one possible way to meet the intent of this recommendation, and to achieve an accurate final approach trajectory and touchdown point in such conditions.

Guidance on "enhancing flight crew position awareness relative to the landing runway during approach" solutions

This guidance is focused on an alternative or complementary solution (i.e., enhancing flight crew position awareness relative to the landing runway during approach). It is apparent that technology maturity may vary by aircraft type (e.g., business and corporate operators, mainline carriers) and a given solution may not fit the needs of all operators and manufacturers. Some solutions are already in operational service. It also needs to be taken into account that in some cases, the solution will be suitable only for forward-fit due to the technology and system architecture needs, whereas other simpler solutions may also be available for retrofit purposes. The purpose here is to provide a high-level outline of the breadth of position awareness solutions that are available, and where they are not available, manufacturers should consider maturing technology to the point where such solutions can benefit the entire fleet.

Position awareness systems fall into one of two flight deck functions:

- Strategic awareness (e.g., navigation display, EFB moving maps), and;
- Tactical cues (e.g., primary flight display [PFD], synthetic vision system [SVS], head-up display [HUD]). Among tactical cues, head-up functions can be used as an aid throughout the approach and landing.

Examples are given below, and each solution needs to be weighed against the current state-of-the-art and architectural limits of a specific aircraft type or aircraft family.

Improved tactical position awareness during approach can be provided by one of more of the following:

- HUD and/or SVS that provide cues such as conformal runway symbols, extended runway centrelines, distance-to-go markers, conformal lateral deviation scales, flight path symbol (FPS), and runway distance remaining upon touchdown. Among these solutions, only head-up functions should be used as an aid in the final stages of the approach down to the landing. Cues such as the FPS and runway symbology provide enhanced situational awareness down to the touchdown point, including during crosswind conditions.
- Systems such as enhanced vision systems can be fused with HUD and/or SVS imagery to provide additional situational awareness.

Figure 16 shows a notional SVS with an FPS, FMS selected runway and airport (cyan rectangles), conformal lateral deviation and extended centreline to the runway. All enhance position awareness with respect to the landing runway.

Note that EUROCAE – ED-249 (Minimum Aviation System Performance for Aircraft State Awareness Synthetic Vision Systems) provides high-level requirements for continuous awareness of attitude, altitude, topography and energy state (speed, acceleration and altitude) related to the flight path and perceived motion of the aircraft.

Figure 16. **Notional SVS depiction on approach**

Courtesy Honeywell

Recommendation MAN10: Aircraft manufacturers and flight data analysis (FDA) service providers should provide adequate interfaces and consider developing additional services for FDA, to help operators identify precursors to runway excursions.

For example, this could include services to identify:

- Discrepancies on runway surface conditions (comparing experienced conditions with ATC reported conditions); and,
- Reduced aircraft performance margins at landing or takeoff, by comparing actual data (such as deceleration and distances) with the expected aircraft performance according to manufacturer models.

FDA (also designated as flight data monitoring or flight operational quality assurance) is the routine collection and analysis of flight data to develop objective and predictive information for advancing safety. It includes the systematic monitoring of exceedances such as excessive vertical speed or long flare, as a means to identify operational risks and feed observations back to the concerned flight crew and evidence-based training and may support an operator's safety management system. An FDA programme is prescribed by ICAO Annex 6 Part I, for commercial operators of aeroplanes with a maximum certified takeoff mass of more than 27,000 kg.

There is existing guidance for the implementation of flight data monitoring precursors published by European Operators Flight Data Monitoring forum, which contains 34 precursors that can be implemented by an FDA programme to monitor the risk of runway excursion. It allows aircraft manufacturers and FDA service providers to identify the necessary flight parameters and FDA algorithms to monitor this risk.

On-board alerting systems such as ROAAS recognize that, despite such digressions from the expected pilot performance, there may not be an operational risk while some operations are inherently more exposed due to systemic issues. For example, when operating from a long runway in good conditions, a ROAAS type system may be very tolerant of reduced braking effectiveness due to aircraft systemic issues. If a crew were to take those conditions to a short runway, they may find themselves using up any safety margin. Another example would be if an aircraft had an issue where it was not able to produce full takeoff thrust. On a longer runway, this might not be noticed; with sufficient data and models to support an accurate prediction of aircraft performance, the issue can be identified. The goal of this recommendation is to provide sufficient aircraft data and expected results so that degraded capabilities, such as in these examples, can be identified during post-flight data analysis.

Technology is now available to perform more integrated analysis of flight data and to compare the observed aircraft performance to aircraft performance models and analyse the results to identify operations that have objectively a higher exposure to events such as runway excursions.

Two possible applications can directly be derived from existing on-board systems:

- Energy-based flight path analysis to identify occurrences, even momentary during the approach, of reduced margin to stopping before the runway end (post-flight ROAAS); and,
- Identification of reduced available runway braking action (post flight ABAR – aircraft braking action report).

While ROAAS is designed to prevent a runway excursion on a given flight, a statistical analysis can highlight approach procedure design, or ATC practices, that more frequently put the aircraft in a high-energy state during the approach that is critical in terms of its performance capability. This allows adapting procedures in an informed and objective way.

ABAR-generating systems are becoming available for some aircraft types but may not be compatible with all fleets. For post-flight analysis, these compatibility issues typically do not exist. Statistical analysis of deferred ABARs can identify deficiencies of the runway surface that create slippery conditions when wet, or instances where the airport report was not accurate as to the effect on aircraft performance. Such information can be used for crew briefing and performance planning, as well as fed back to the airport, which can inform users accordingly and plan maintenance action.

These two types of observations could be combined to identify instances where performance capability would have been marginal with regards to the available runway length for the observed runway condition.

It should be noted that should the additional data needed to support this recommendation be added in conjunction with the initial design of the aircraft, or in concert with other planned updates, the commercial impact should be minimal.

Recommendation MAN11: Manufacturers should consider a real-time takeoff performance monitoring function in order to reduce the risk of runway excursion during takeoff, including aircraft performance-related or wrong-position scenarios.

There have been several takeoff performance-related events over this last decade. Even though sufficient margins were available in most of them, these are high risk situations potentially leading to a tail strike or a runway overrun.

Erroneous parameters, when used for the performance calculation, can lead to incorrect takeoff speeds or thrust computations. On other occasions, takeoff data wrongly inserted in the flight management system or not updated following a late runway change can lead to takeoff without the correct performance data.

In-service experience shows a number of events where aircraft have started takeoff from a taxiway intersection when the computed performance was for the entire runway length, where takeoffs have started from the opposite QFU (the opposite end of the assigned departure runway), from a different runway than the planned runway, or even from a taxiway. Finally, a few cases of residual braking leading to an abnormal aircraft acceleration were reported during the takeoff roll.

Most of these events can be avoided by complying with the SOPs. Indeed, several cross-checks enable the flight crew to identify discrepancies. These examples, however, show that errors can still be made, typically in stressful situations, with high crew workload, last minute changes or demanding ATC requests.

Therefore, manufacturers should consider developing takeoff performance monitoring functions aiming at reducing the risk of runway overrun.

These functions should timely warn the crew in case the considered takeoff performance parameters (e.g., mass, speeds, thrust, flaps and runway) do not allow a safe takeoff. Such a function should consider the aircraft real-time position within the airport at takeoff initiation, in order to cover scenarios such as a takeoff attempt from a wrong runway, a wrong intersection or even a taxiway. These functions should also monitor the evolution of the real measured takeoff roll against the expected one.

Note that airport moving maps provide additional crew awareness of position relative to runways and taxiways, and these systems have the potential to mitigate errors associated with incorrect runway, incorrect intersection, or inadvertent taxiway takeoffs. Other systems (if equipped) can provide an alert if the aircraft attempts a departure from a runway other than that programmed in the FMS (FMS runway disagree) or attempts a taxiway takeoff (e.g., runway awareness and advisory system).

References

Takeoff Surveillance & Monitoring Functions — Safety First | October 2019 — Airbus S.A.S. (*https://safetyfirst.airbus.com/takeoff-surveillance-and-monitoring-functions/*)

Improving Runway Safety with Flight Deck Enhancements, *Boeing Aero Magazine*, Quarter 1, 2011. (*https://www.boeing.com/commercial/aeromagazine/articles/2011_q1/pdfs/AERO_2011_Q1_article2.pdf*)

Recommendation MAN12: Manufacturers should consider making available systems that provide flight path and energy state awareness in order to aid the flight crew to better anticipate and maintain stability throughout the approach.

The objective is to enhance flight crew awareness of flight path and aircraft energy state during approach and reduce the need for late go-arounds.

Current systems such as head-up guidance systems (HGS) can have a positive influence on a flight crew's situational awareness and risk perception, thereby improving decision-making. The use of a HGS for all approaches may help the pilots in their decision-making as well, because most HGS provide for a 3-degree slope indication, indicate the flight path and have a guidance line for the touchdown point. Using HGS for all approaches may assist the pilots in flying stabilised approaches. This is especially true for visual approaches when no vertical guidance (e.g., ILS, precision approach path indicator [PAPI], visual approach slope indicator [VASI]) is available. Some HGS systems also have a feature that shows show the runway remaining after touchdown.

Note also that many SVS incorporate very similar flight path and energy cues on head-down displays such as the PFD (e.g., FPS, acceleration and speed cues, flight path reference line, runway distance remaining) and that such symbols may also be present on PFDs without SVS terrain functionalities

The HUD and many SVS systems present information that is flight path-based, and the influence of factors such as crosswinds, drag and power is reflected in the information shown. For example, during a crosswind condition, the FPS should be pointing to the runway, irrespective of the current aircraft heading during a crab (i.e., the direction the aircraft's nose is pointing). For FMS-coupled approaches, the HUD and/or SVS information is an effective way to monitor the approach. HUD and SVS energy information is typically depicted in reference to the FPS, and both a speed error tape and acceleration cues are presented.

The above display cues provide enhanced flight path and speed awareness and aid the crew in maintaining a stable approach.

Where such systems are not already available or the technology has not matured to the required technology readiness level, such systems should be considered and made available to operators when beneficial for aircraft operations. Evaluations of the benefits of such functions should be performed based on in-service data and experience shared when and where available. It is understood that the provision of such technologies is influenced by multiple factors (technology maturity, architectural limitations, forward-fit versus retrofit needs, etc.), and the necessary trade-offs to provide such capabilities will need to be made.

Figure 17 (p. 120) provides an example of SVS that provides enhanced path and energy awareness cues.

References

EUROCAE – ED-249 (Minimum Aviation System Performance for Aircraft State Awareness Synthetic Vision Systems).

Commercial Aviation Safety Team (CAST) identified Safety Enhancement SE 200.

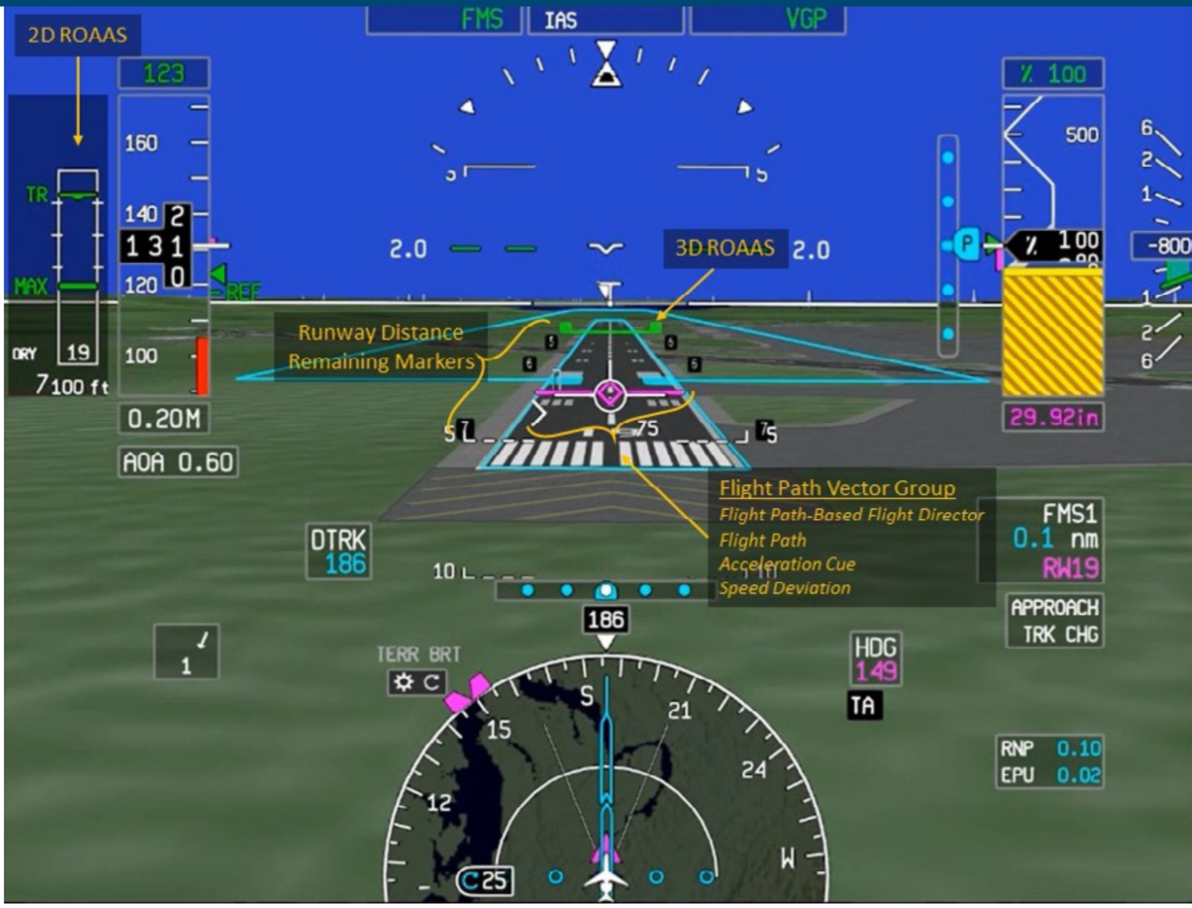
Recommendation MAN13: Manufacturers should provide recommendations in their operational documentation for the use of automatic braking when landing on wet or contaminated runways, when appropriate, to minimize delays in brake application.

When landing on wet or contaminated runways, the flight crew has to focus on multiple actions to ensure that landing can be performed safely. One priority is to make the best use of runway length available by targeting an accurate touchdown point (both longitudinal and lateral) and keeping the aircraft as close as possible to the centreline to avoid any lateral deviation on these low-friction runway states. Flight crew must also ensure that braking and reverse applications are performed with minimal delays.

The use of automatic braking allows the release of constraints on flight crew for minimising delays in brake application. It also provides symmetrical braking during the landing roll.

It is recommended that aircraft manufacturers provide recommendations in their airplane flight manual or operational documentation for the use of automatic braking when landing on wet or contaminated runways.

Figure 17. **Example SVS with enhanced path and energy awareness**



Courtesy of Honeywell

Recommendation MAN14: Manufacturers should consider making available on-board real-time stabilised approach monitoring systems that provide alerts when there is a deviation from stable approach criteria. In those cases where other alerting systems are used in combination (e.g., ROAAS), the alerting systems must be consistent to avoid unnecessary go-arounds.

Stabilised approach is a key element for safe approach and landings. Failing to establish and maintain a stabilised approach may potentially result in abnormal runway contact, controlled flight into terrain (CFIT), in-flight damage, loss of control in–flight (LOC-I), runway excursion, tail strike or undershoot. During the 2009–2018 period, 49 percent of fatal accidents in commercial aviation occurred during final approach and landing phases, resulting in 903 on-board fatalities [reference below, Boeing Statistical Summary].

An approach is stabilised only if all the criteria in company SOPs are met before or when reaching the applicable minimum stabilization height. The recommended minimum stabilization heights are 1,000 ft above airport elevation in instrument meteorological conditions (IMC), or 500 ft above airport elevation in visual meteorological conditions (VMC).

The stabilised approach monitoring system is intended to increase situational awareness by monitoring stabilised approach criteria and providing timely awareness for the crew, in order to minimize unstabilised approach occurrences.

- The system should consider monitoring the approach elements presented by FSF ALAR Toolkit — Briefing note 7.1 — Stabilized Approach, as practical;
- The system should automatically check elements and provide timely feedback for the crew;
- The system should inform the crew which stabilised approach element is not being met during an unstabilised approach;
- The system should be harmonized with other systems used in the same phase, in terms of alerts, pilot inputs and procedures. Other systems examples may be listed, but not limited to: terrain awareness and warning system (TAWS), ROAAS and landing gear alerts, among others; and,
- The system should not be intrusive (i.e., to preserve the crew's attention to ATC clearance/messages) and not lead to unnecessary go-arounds (e.g., too frequent alerts when not fully justified) that could risk to overcome ATC

capability, and should fit with existing SOPs, recommendations and callouts.

References

BOEING: Statistical Summary 2018.

Flight Safety Foundation: ALAR Briefing Note 7.1 — Stabilized Approach.

IATA et. al: Unstable Approaches — Risk Mitigation Policies, Procedures and Best Practices, 2nd ed 2016.

NTSB, Safety Alert 077 — Stabilized Approaches Lead to Safe Landings, 2019.

Improving Runway Safety with Flight Deck Enhancements, Boeing Aero Magazine, Quartet 1, 2011. (*https://www.boeing.com/commercial/aeromagazine/articles/2011_q1/pdfs/AERO_2011_Q1_article2.pdf*

Recommendation MAN15: Manufacturers should provide on-board real-time means to enhance position awareness with respect to runways on final approach and ground operations to address risks of aircraft lining up on:

- The incorrect runway for landing or departure;
- A taxiway for landing or departure; or,
- The incorrect intersection for departure.

Selection of the wrong runway for takeoff or landing can invalidate any performance computations done to ensure a safe takeoff or landing. Providing the crew with improved position awareness, or awareness when the available runway surface appears to be atypically short, can help a crew avoid beginning a takeoff or approach to a runway that was not planned.

Airport moving maps provide additional crew awareness of position relative to runways and taxiways. These systems have the potential to mitigate errors associated with incorrect runway, incorrect intersection or inadvertent taxiway takeoffs. The systems are typically part of an EFB or installed avionics (e.g., on the navigation display).

Other flight deck systems (if equipped) provide an alert if the aircraft attempts departure from a runway other than that programmed in the FMS or attempts a takeoff or landing on the taxiway (e.g., runway awareness and advisory system [RAAS]).

References

Improving Runway Safety with Flight Deck Enhancements, Boeing Aero Magazine, Quarter 1, 2011. (*https://www.boeing.com/commercial/aeromagazine/articles/2011_q1/pdfs/AERO_2011_Q1_article2.pdf*

Runway Awareness and Advisory System *https://www.skybrary.aero/index.php/Runway_Awareness_and_Advisory_System_(RAAS)*

Recommendation MAN16: Whenever new functionality is created that is not supported by existing regulatory guidance, that functionality should be preferably supported by development of minimum operations performance standards (MOPS) by a standards organization.

New aircraft technology that is not covered by existing regulations is often certified via standards that are not published and made available to the rest of the aviation community. This situation can make wider adoption of similar technology more difficult for other manufacturers and can produce products with related functionality but dissimilar operating characteristics, including displays, controls and even basic operating capabilities.

By collaborating with other industry organizations and regulators, common rules can be established and made known, which permits other adopters of similar technology to have validated requirements for design and can create a standard level of performance for all implementations. There are many organizations that help facilitate development of this type of standard for aviation technology, such as the European Organisation for Civil Aviation Equipment (EUROCAE); RTCA, formerly known as the Radio Technical Commission for Aeronautics; and SAE International.

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APPENDIX E
GUIDANCE AND EXPLANATORY MATERIAL FOR REGULATORS AND ICAO

Effective oversight of runway, aerodrome and flight operations should continue to form an important part of the safety management system of the aerodrome operator, air navigation service provider (ANSP), aircraft operator, other stakeholders and of the state safety program activities.

Under the Convention on International Civil Aviation, States are responsible to ensure safety, regularity and efficiency of aircraft operations, air navigation services and operations at aerodromes under their jurisdiction. Therefore, it is essential that the State exercises its safety oversight responsibilities and ensures that aircraft operators, ANSPs and aerodrome operators comply with the applicable national/regional regulations, which are built on the relevant International Civil Aviation Organization (ICAO) Standards and Recommended Practices.

The regulatory authority responsible for safety oversight should conduct regulatory oversight and inspections on aircraft and aerodrome operators as well as ANSPs in order to monitor the safe provision of these operations and to verify compliance with the regulatory requirements.

The oversight of aircraft operators, ANSPs and aerodrome operators by their regulator should include at least the following:

- Ensuring that aircraft operators, ANSPs and aerodrome operators have developed, implemented and continue to maintain an effective runway excursion prevention programme that meets national/regional requirements;
- Conducting audits and inspections to examine the interfaces between the aerodrome operators and other stakeholders involved in runway excursion prevention (e.g., communication of safety-significant information regarding changing surface conditions in real time to the appropriate air traffic services providers);
- Reviewing and continuously improving the training program for pilots, air traffic controllers, aerodrome flight information service officers and aerodrome personnel on runway excursion prevention measures;
- Reviewing operators' incident prevention programs, including occurrence reporting relating to runway excursions; for aircraft operators, this should include monitoring aircraft parameters related to potential runway excursions from their flight data monitoring program;
- Reviewing the training programs for air traffic controllers to ensure that the subject of 'stabilised approaches' and aircraft energy management is included;
- Reviewing runway maintenance programs, including removal of contaminants, refurbishing programs, and the assessment of runway contamination and friction levels in line with the latest, national/regional requirements; and,
- Reviewing the noise mitigation measures through hazard identification and risk assessment for aerodromes ensuring coordination between the organisation managing the change and other stakeholders.

In addition to the regulatory oversight, it is beneficial that a regulator keeps a high level, national focus on the risk of runway excursions. This can be achieved by establishing a national runway safety forum. Membership in the forum should include representatives from aerodromes, aircraft operators' flight operations, air traffic services, industry safety groups, local runway safety teams and the regulatory authority.

Terms of reference for such a group should be to:

- Address specific hazards identified nationally, coordinating this through sub-groups or external agencies as required;
- Promote good practices and information sharing, raise awareness through publicity and educate the industry;
- Actively enhance work continuing in industry and act as a point of coordination for industry;
- Identify and investigate which technologies are available that may reduce runway excursion risks and promote their use;
- Review current aerodrome, air traffic control and aircraft operational procedures and, if necessary, make recommendations on future policy, guidance and advisory material for all stakeholders to reduce the risk of runway excursions; and,
- Oversee the reporting of runway excursion incidents and utilise the data to highlight issues and trends.

Regulators should continue to actively support and promote the Global Action Plan for the Prevention of Runway Excursions (GAPPRE) as part of state safety program activities. Although GAPPRE contains recommendations only, regulators should ensure that it is given appropriate consideration in oversight activities by:

- Promoting awareness of GAPPRE;
- Conducting an operators gap analysis to ensure that all recommendations are implemented;
- Ensuring that runway safety and the prevention of runway excursions are addressed in regular audit inspections;

- Ensuring that the findings and recommendations arising from audits are implemented; and,
- Working collaboratively with other regulators and ICAO to ensure that the signs, markings and lighting systems of the runway environment and associated procedures are appropriate for all day, night and reduced visibility operations and, where necessary, develop improvements and enhancements as required.

ICAO should support and promote GAPPRE as part of the ICAO Runway Safety Programme, its regional activities and the work of the respective panels and working groups. This should include but should not be restricted to:

- Investigating measures to support flight crew to enable differentiation between the runway centreline lights and the runway edge lights. This may include, for example, differentiation by colour, luminosity or pattern;
- Considering provisions in Annex 14 that de-couple the provision of taxiway centreline lights from traffic density. This is currently foreseen in recommended practice 5.3.17 of ICAO Annex 14. In practice, the taxiway centreline lights are also used for the guidance of the individual aircraft (irrespective of the traffic density) and not just for their control in the context of an aerodrome's surface movement guidance and control systems. Moreover, this should take into account that occurrences of misaligned takeoffs have taken place at aerodromes where the taxiway leading to the runway entry was not equipped with taxiway centreline lights, and that the investigation of these occurrences has shown that the misaligned aircraft (they were aligned with the runway edge lights during their takeoff) were operating alone with no other traffic present;
- Investigating measures to enhance flight crew positional awareness in the runway touchdown zone during approach and landing. Specifically, the improvement of the visual aids may include, for example, lighting systems indicating the end of the touchdown zone. This will help flight crew, especially in conditions where runway markings are difficult to observe, to have an optimal flare and to decide whether to go around, when the timeliness of the decision is a critical parameter affecting the runway excursion risk;
- Investigating the possibility of upgrading to a standard the use of simple touchdown zone lighting. This may enhance flight crew awareness of the touchdown zone and will increase touchdown point accuracy, which is a critical risk factor for the runway overrun risk.
- Investigating the possibility of increasing the use of runway centreline lights to include more operations. This is because there have been numerous runway excursions (either high speed overruns or veer-offs), during both the landing and the takeoff phase, whose investigation has identified the existence of a runway centreline lighting system as a measure that could have prevented the events.
- Investigating potential regulatory measures to develop detailed rules for the maintenance of manoeuvring area signs.

Specific rationale and explanatory material related to recommendation REG16: Support the development of approved signal-in-space SBAS models to allow certification of automatic landing on LPV 200 procedures as part of a wider initiative to promote and encourage the development of LPV 200 instrument flight rules procedures on a wider set of runways.

States and/or regions developing SBAS systems capable of supporting LPV 200 (localizer performance with vertical guidance) approach procedures should support with data and/or detailed specification the creation, validation and publication of signal-in-space models to enable the certification of automatic landing with LPV 200. These signal-in-space models shall include nominal performances (e.g., including all nominal variability of the signals), and failures case definitions. Certification authorities should recognise these signal-in-space models as acceptable means to demonstrate adequate automatic landing performances based on SBAS. The rational includes:

- The certification of aircraft automatic landing systems as per all weather operation regulations requires demonstration of acceptable landing performance. To perform this demonstration, acceptable means of compliance is to rely on simulation and flight tests. The simulation requires a signal-in-space model representative of nominal distribution of errors and failure cases of the navigation means used to support the operation.
- The allowed minimums of an LPV 200 procedure are not intended to be changed by the use of an automatic landing system.
- LPV 200 procedures are expected to be rapidly deployed in regions where SBAS systems supporting LPV operations have been developed. Observed performance of SBAS-in-space in regions where it is deployed has been fully compatible with existing certified automatic landing systems. However, we are currently lacking approved signal-in-space models to certify automatic landing capacity based on SBAS. Such capacity would support the R&D recommendation R&D1, and Aircraft MAN9. Efforts to develop such models have been constrained by the lack of data availability and an approved methodology. In particular, details on normal distribution of errors and ground-based monitoring thresholds are difficult to obtain, and only the specifications may be known. Lack of a failure case model prevents the failure case assessment from being performed at the aircraft level (for example for ILS case and GBAS case, the monitoring thresholds are published in standards).

As different SBAS systems are being deployed worldwide, it is expected that performance of these systems might slightly differ and that each system would require a specific signal-in-space model.

APPENDIX F
GUIDANCE AND EXPLANATORY MATERIAL ABOUT GEM RECOMMENDATION R&D RECOMMENDATIONS

The main reason for including recommended R&D topics in the GAPPRE document is that the different experts who participated in the development of GAPPRE felt that some technologies needed more research and development before they could be used in operations. Also, some technologies must still mature for real-world systems development to ensure that they meet the intended function of reducing runway excursions. The list of recommended R&D topics can help to define research projects in the future.

This appendix contains background information on the recommended R&D topics.

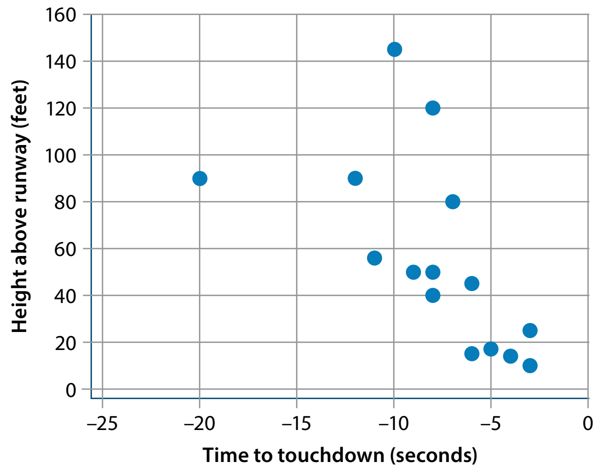
R&D1: Investigate an awareness and alerting system when an aircraft experiences abnormal/significant lateral deviation during final stages of the landing.

Occurrence data have shown that in a number of veer-offs during the landing phase, the aircraft had started to deviate from the lateral track before touchdown. An example of such cases is shown Figure 18. This shows the start of the lateral deviation as function of time to touchdown. In most of these runway excursions, the deviation started around or just after passing the runway threshold. The lateral deviation was often caused by some crosswind which was not compensated for by the pilots or by incorrect control inputs by the pilots, often in combination with a lack of outside visual references (e.g., due to sudden heavy rain, when passing the threshold). An awareness and alerting system that informs or warns pilots of the lateral deviation before touchdown could help reduce these types of runway excursions.

One challenge is that such an awareness/alerting system would need to be triggered sufficiently ahead of the touchdown to allow appropriate time delay for crew action (otherwise it may add confusion without allowing the required time for trajectory correction or go-around). Expected crew procedures for this alert would have to be defined. Nuisance alerts should be minimised to avoid alerting if crew adequately manoeuvre the aircraft to correct wind variations that may occur in the late final approach. Finally, the awareness/alerting system will have to rely on navigation means to adequately estimate risk of lateral excursion; this would require a high level of navigation mean accuracy and integrity in order to minimise the nuisance rate. Details of such a system should be developed and the system should be evaluated (e.g., in a simulator) to determine the actual benefits. Development of this system has not yet started.

The system would mainly benefit commercial transport aircraft that do not have automatic landing capabilities or have a head-up display installed to help to provide lateral guidance. It is unclear at this moment if it could be introduced as a retrofit or only for new designs.

Figure 18. **Start of lateral deviation as function of time to touchdown in runway veer-off accidents, 01/01/2012 to 07/07/2014**



Source: H. Nelson, *A Review of Runway Excursion*, Airbus, 2015

References

D3.16 – Flight Data Monitoring Workshop: Runway Veer-off Risk Monitoring Tools, Future Sky Safety, *https://www.futuresky-safety.eu/download/*

H. Nelson, *A Review of Runway Excursion*, Airbus, 2015.

R&D2: Conduct research on transport-category aircraft, to extend automatic landing capacity to any runway state.

Lateral control of aircraft during the landing roll-out phase is a complex interaction of rudder input and lateral forces acting on the airframe (with crosswind) and tires. In particular, the lateral friction forces on the aircraft tires are complex whenever there is a combination of cornering and brake application (e.g., during landing in crosswind). Different engineering models are used to capture these characteristics for a variety of runway conditions. Only part of the directional control characteristics envelope can be safely examined and validated in flight testing that is mostly limited to dry runways. The idea is to define standard models for lateral friction on degraded runway states and acceptable means of compliance to demonstrate roll-out performance for different runway states and crosswind conditions. Currently, aircraft manufacturers use their own developed models for lateral friction forces on tires. They do not have approved lateral friction models for degraded runway state or sometimes even for a dry runway. Lack of such standard models prevents automatic landing performance demonstrations from being done by simulation. Similar to standards for wheel braking friction (see, e.g., EASA CS 25.109, and EASA AMC 25.1591), standard models for the lateral friction forces should be developed for different runway states (dry, wet and contaminated). These models should account for the effect of brake application.

References

D3.2 – Shortcomings in current modelling for modern aircraft, *https://www.futuresky-safety.eu/wp-content/uploads/2016/02/FSS_P3_NLR_D3.2_ES_v2.0.pdf*

Expansion of flight simulator capability for study and solution of aircraft directional control problems on runways, NASA CR-145084, 1978.

Enhancement of Aircraft Ground Handling Simulation Capability, Advisory Group for Aerospace Research and Development, AGARDograph-333, 1998.

R&D3: Improve methods for assessing runway micro texture. Make pilots and aerodrome operators aware of the impact of a poor micro texture and of the shortfalls of current industry practice.

Over the years, a number of runway overrun accidents and incidents have occurred after the aircraft landed on a wet runway. An analysis of the aircraft stopping performance in these events indicates that the wheel braking friction coefficient achieved during the landing roll was significantly less than the coefficient predicted by industry-accepted models, and less than assumed in the wet-runway landing distance advisory data provided in the manufacturers' airplane flight manuals. The wheel braking friction coefficient that can be assumed on a wet runway during an aborted takeoff is specified by 14 CFR 25.109 or EASA CS 25.109. The 25.109 model has been proposed and used for computing landing distances on a wet runway as well. In a number of runway overruns, there were no clear indications that the runway would be slippery when wet. It is believed that deficiencies in the runway micro texture have resulted in the lower wheel braking friction levels. The wheel braking friction coefficients specified in FAR/CS 25.109 are based on generalized curves originally developed by engineering design organization ESDU. These ESDU curves were based on data for runways having a sharp micro texture. For wet runway surfaces having a smooth micro texture, the standard curves of 25.109 overestimate the braking friction capabilities of aircraft tires. An example of such an overestimation is shown in Figure 19. In this example, a slippery wet condition (RCR = 3) matches the achieved braking friction levels much better. At this moment, there are no acceptable methods for assessing the runway micro texture. Research is therefore needed on methods that airports can use to assess the runway micro texture. Whenever the micro texture level is below a defined threshold, the runway could be declared 'Slippery wet' (e.g., RCR = 3). This could also initiate runway resurfacing. Explorative research has shown that high resolution laser scanners can help to assess the micro texture characteristics of a hard surface. However, further research is needed to validate this technique for runways and to define thresholds that can be used by airports. Correlation of laser scanner results with full-scale flight test data is also needed as part of the validation process. Aircraft full braking tests on wet runways with different micro textures should be conducted and compared to results obtained with high resolution laser scanners.

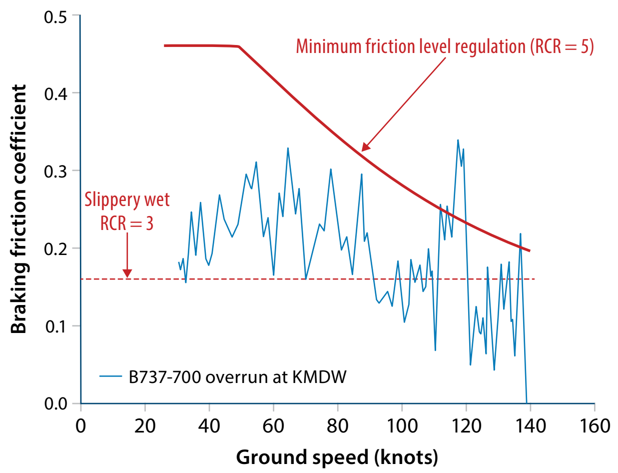
References

J. O'Callaghan. Slippery When Wet: The Case for More Conservative Wet Runway Braking Coefficient Models, National Transportation Safety Board, AIAA AVIATION Forum, 2016.

Topic 9 Wet Runway Stopping, FAA Aviation Rulemaking Advisory Committee FTHWG Phase 2, 2018.

EASA Research Agenda 2020 *https://www.easa.europa.eu/sites/default/files/dfu/easa_research_agenda_2020-2022.pdf*

Figure 19. **Example of low braking friction on a wet grooved runway**



Source: NTSB, NLR

R&D4: Develop models for assessing runway wetness, particularly the depth.

Airports often struggle to give accurate information regarding the wetness of their runways during operations. Simple empirical models have been developed over the years that predict the water film depth on a surface as a function of rainfall, location and runway topography (slopes and texture). Some of the empirical models that are currently used do not always agree well with experimental data (other than those data used to develop the equations) and cannot account for surface wind. The empirical water depth models are often developed using data obtained for road surfaces. Research is needed to further improve the models for runway surfaces, including grooved surfaces. Also, the concept of operations of such models in an airport environment need to be developed. The use of water film models have been tested at airports with some success.

References

Gallaway, B. M., Pavement and geometric design criteria for minimizing hydroplaning, U.S. Federal Highway Administration; its R&D report no. S-0929, 1979.

Gallaway, B.M., Schiller, R.E., Jr. and Rose, J.G., The Effects of Rainfall Intensity, Pavement Cross Slope, Surface Texture and Drainage Length on Pavement Water Depths, Texas Transportation Institute Report 138-5, 1971.

D3.11 – Assessment of the impact of new concepts reducing the risk of runway excursions, Future Sky Safety Project, *https://www.futuresky-safety.eu/wp-content/uploads/2019/04/FSS_P3_TR6_D3.11_v2.0.pdf*

Accumulation of water on runway, ESDU Data Item 19005, May 2019.

R&D5: Explore the accuracy of and develop new automatic runway condition monitoring systems.

With the introduction of the Runway Condition Assessment Matrix (RCAM) as part of the Global Reporting Format, the need to assess contaminants on a runway has become more critical. Many airports are looking for systems that can automatically detect the runway condition (e.g., type of contaminant and its depth). Mobile, as well as static, monitoring systems are currently available. However, their accuracy is sometimes questionable and the operational limitations are often unclear. Research is needed into the accuracy and working of these systems. There is also a need for design specifications that manufacturers can use when developing the surface monitoring systems. Work on drafting specifications has been started by EUROCAE.

References

Guilhem Blanchard, Antoine Dejean de La Batie, Sébastien Belon, Caractérisation automatisée de l'état de surface des pistes aéroportuaires - État de l'art et perspectives, DGAC-STAC, 2019.

Minimum Aviation System Performance Standards (MASPS) for Runway Weather Information Systems, EUROCAE WG-109 (to be published in 2021).

R&D6: Research ways to improve graded area of wet runway strips to mitigate the damage to aircraft when veering off a runway.

A function of the graded area of a runway strip is to reduce the risk of damage to an aircraft running off the runway. For this reason, airports have to comply with International Civil Aviation Organization (ICAO) standards that define the limits of how much an aircraft's landing gear can sink into the soil in the graded area. The runway strip and graded area must meet specific longitudinal and transverse slopes, and bearing strength requirements. Because the graded portion of a strip is provided to minimise the hazard to an aircraft running off the runway, it should be graded in such a manner as to prevent the collapse of the landing gear of the aircraft. The surface should be prepared in such a manner as to provide drag to an aircraft, and it should have sufficient bearing strength to avoid damage to the aircraft. To meet these divergent needs, the following guidelines are provided for preparing the strip. Aircraft manufacturers consider that a depth of 15 cm is the maximum depth to which the nose gear may sink without collapsing. Therefore, it is recommended by ICAO that the soil at a depth of 15 cm below the finished strip surface be prepared to have a bearing strength of a California Bearing Ratio (CBR) value of 15 to 20. The intention of this underlying prepared surface is to prevent the landing gear from sinking more than 15 cm. This requirement is tested under dry surface conditions. Aircraft veer-off accidents have shown that in many cases, the gear collapsed when running over the graded area of the runway strip when it was wet from rainfall. The relatively low shear strength of unpaved runway surfaces when wet limits aircraft loads imposed on the runway. There could be a need to develop graded areas which do not have this shortcoming. Research in this area is therefore recommended.

References

M. Crispino et Al. "Soil Improvement of Runway STRIP and Runway End Safety Area (RESA) through an Innovative Methodology." Proceedings of the First Congress of Transportation and Development Institute, 2011.

Aerodrome Design Manual, ICAO Doc 9157.

R&D7: Research and develop functions that provide additional flight path and energy information (such as flight path vector symbology) in order to help the flight crew to better anticipate and maintain stability at the gate and below.

The objective is to enhance flight crew awareness of the aircraft energy state during approach and reduce the need for late go-arounds.

Current systems such as head-up guidance systems (HGS) can have a positive influence on a flight crew's situational awareness and risk perception, thereby improving decision-making. The use of an HGS for all approaches may help the pilots in their decision-making as well because most HGS provide for a 3-degree slope indication, indicate the flight path and have a guidance line for the touchdown point. Using HGS for all approaches may assist the pilots in flying stabilised approaches. This is especially true for visual approaches when no vertical guidance (e.g., instrument landing system, precision approach path indicator, visual approach slope indicator) is available. Most HGS systems also have a feature that shows the runway remaining after touchdown.

Note also that some synthetic visions systems incorporate similar energy management cues on head-down displays such as the primary flight display (e.g., flight path vector, acceleration and speed cues, flight path reference line, runway distance remaining).

Where such systems are not already available or the technology has not matured to the required technology readiness level, such systems should be developed and made available to operators. Evaluations of the benefits of such functions should be performed based on in-service data and experience when/where available.

R&D8: R&D efforts should be conducted to develop on-board real time stabilised approach monitoring (upstream of ROAAS function at higher altitudes e.g., Flight Level 200). Such systems should ensure that they are harmonized with other systems such as ROAAS and the runway awareness and advisory system (RAAS).

Numerous runway excursions are related to unstable approaches. Some flight deck systems such as the runway awareness and advisory system (RAAS) already provide aural and/or visual alerts when stabilised approach criteria are being violated (e.g., too fast, too high). Other systems such as the runway overrun awareness and alerting system (ROAAS) provide instantaneous information, such as predicted stopping points, to the pilots. These systems typically function at altitudes below 1,500 ft. Earlier awareness of such conditions beginning at the start of the descent would lower the number of unstable approaches. The objective is to reduce the risk of unexpected energy/trajectory conditions (leading to possible go-arounds) when approaching landing decision gates. R&D efforts should be conducted to develop a real-time strategic awareness and alerting function to enable appropriate energy management throughout the descent (from top of descent) and approach, upstream of the ROAAS/RAAS protection domain. This function should ideally account for current and predicted energy conditions, air traffic control (ATC) change requests, winds conditions, etc., and provide path adaptation and configuration management cues, and alerting when unsafe landing conditions are predicted.

The system should assist in timely planning and predicting an optimized trajectory, taking into account the current energy and trajectory state and the ATC change requests, and giving guidance to the crew to anticipate future sequence of actions for energy dissipation on this optimized profile (e.g., configuration change).

Organisations that supported the initiative

www.eurocontrol.int