September 23, 2019

Mr. Brandon Roberts
Office of Rulemaking
Acting Designated Federal Official, Aviation Rulemaking Advisory Committee
Federal Aviation Administration
800 Independence Avenue, SW
Washington, DC 20591

RE: Airman Certification Working Group (ACSWG) Interim Recommendation Report and Flight Test Harmonization Working Group Topic 20 Final Recommendation Report

Dear Mr. Roberts,

On September 19, 2019, the Aviation Rulemaking Advisory Committee (ARAC) voted to accept the Interim Recommendation Report submitted by the Airman Certification System Working Group (ACSWG). This report covers Airmen Certification Standards for Airline Transport Pilot and Type Rating for Powered-Lift.

The ARAC also voted to accept the Final Recommendation Report submitted by the Flight Test Harmonization Working Group (FTHWG) on Topic 20 – Return Landing Capability.

On behalf of the ARAC members, please accept the ACSWG Interim Recommendation Report, submit to the relevant program offices and move forward to the establishment of a public docket. Please also accept the FTHWG Final Recommendation Report and submit to the relevant program offices for consideration and implementation.

Please do not hesitate to contact me with any questions. Thank you very much.

Sincerely yours,

Yvette A. Rose
ARAC Chair

cc: David Oord, ACSWG Chair and ARAC Vice Chair
Keith Morgan, TAE Chair
Brian Lee, Boeing

FAA Aviation Rulemaking Advisory Committee
FTHWG Task 20
Return Landing Capability

Recommendation Report
July, 2019

Table of Contents

Executive Summary

The Flight Test Harmonization Working Group (FTHWG) was tasked to recommend appropriate revisions to return landing capability regulatory and advisory material (refer to work plan Attachment 20A). Return landing is sometimes referred to in industry jargon as return-to-land, or RTL.

The primary concern of this topic was airplane system failures (and other events) occurring soon after takeoff that could result in performance deficiencies during heavy weight return or diversion landings. The design requirements and operating procedures employed by airplane manufacturers should result in airplane designs with enough performance capability in these non-normal situations to allow safe landings.

The task consisted of reviewing the related FAA/EASA/TCCA/ANAC Part 25 regulatory and advisory material, reviewing issue papers published for recent certifications and OEM best practices, and producing harmonized criteria to address the safety concerns associated with heavy weight return landings.

The application of various issue papers by U.S., Canadian, and Brazilian airworthiness authorities has resulted in an uneven playing field between different applicants for return landing capability approval. EASA has not initiated certification review items on this topic.

As a conclusion of this in-depth review, the FTHWG recommends to amend two Part 25 Subpart E paragraphs and to add a new Subpart B requirement to address immediate heavy-weight return or diversion landing capability. Updates to the relevant AC guidance are also proposed to address the new and changed regulations.

This report provides the FTHWG proposed new and revised requirements and guidance to address immediate return or diversion landing capability.

- Fuel Jettisoning System requirements 25.1001(a) and 25.1001(b) were updated to clarify that the intent of the rule does not include flight-in-icing effects on the climb requirements for an immediate return with a missed approach or balked landing. Also, the reference to “and landing” was removed and addressed in a new proposed requirement.
- A new requirement for immediate return or diversion landing is proposed as a design standard for Part 25 airplanes. There are two fundamental hazard scenarios addressed by the requirement; the first for immediate return landings and the second for less urgent landings at a suitable airport. The events and failures to be addressed as part of the airplane design are further defined in the relevant guidance.

To conclude:

- The following Part 25 Subpart E paragraphs are recommended to be updated: 25.1001(a),(b)
- New Part 25 Subpart B paragraphs are recommended: 25.127(a),(b)
- The following AC 25-7D paragraph is recommended to be updated: 25.1
- New AC 25-7D paragraphs for Flight: Performance are recommended: 4.x.1 through 4.x.5
- The following AC 25-22 paragraph is recommended to be modified to reflect the revised 25.1001(a),(b) text: Paragraph 43(a)

The current standards and guidance material are defined in:

- TCCA : AWM 25.1001, Transport Canada Certification Memorandum: FT-19: Immediate Return to Land Capability – Aircraft Certification, Flight Test (AARDC), Aircraft Certification, Fuel and Hydromechanical Systems (AAARDD/M)
- FAA : 14 CFR 25.1001, Chapter 25.1 of Advisory Circular (AC) 25-7D, and Return Landing Capability Issue Papers, Paragraph 43(a) of AC 25-22 – Certification of Transport Airplane Mechanical Systems
- ANAC : RBAC 25.1001 and Return Landing Capability FCARs
- EASA : CS 25.1001

The initial expectations of the working group were that enhancing and harmonizing guidance for § 25.1001 would be sufficient, but the scope of the discussions revealed that there were also issues with the regulations and their effectiveness in addressing the original intent of the rule. The existing regulations did not include adequate flight requirements to address the hazards of overweight return landing including exceedance of flap placard limit speeds, exceeding landing runway length, maximum brake energy, and maximum tire speed. The existing guidance was not specific enough resulting in unnecessary inconsistency in the showing of compliance across the industry. Also, during the working group discussions, the FAA introduced additional concerns for a broader range of failure conditions where the need to land is not urgent but extended flight with these failures is not recommended or expected.

The FTHWG also recommends amending and harmonizing TCCA, EASA and ANAC requirements and guidance, accordingly.

Background

Immediate return and diversion landings occur when unexpected events cause the flight crew to change their planned landing runway. These events may involve airplane system failures or may be caused by other reasons such as security or medical emergencies. If the return or diversion happens soon after takeoff, the airplane may be landing near the maximum takeoff weight (MTOW). When landings are made above maximum structural landing weight (MLW), the landing speeds will be elevated and the landing performance may become critical.

Airplane designs are required to include consideration of landing above MLW and in abnormal configurations that affect landing performance (e.g. with flaps in non-normal landing position, or with less than full braking capability). Operating procedures, airplane flight manual (AFM) information, and advisory data are provided to deal with failures where the increased risk of landing overweight needs to be mitigated. Transport category airplanes are required per § 25.473(a)(3) to be designed to account for landing loads at the design takeoff weight (MTOW is assumed) with a limit descent velocity of 6 feet per second. Operational structural inspections may be required after landing above MLW depending on the descent velocity at touchdown. Most transport airplane designs have thrust reversers installed to assist in airplane deceleration on the ground, and fuel jettisoning systems are installed on some designs as a means to rapidly reduce the landing weight in non-normal situations to reduce landing speeds and required stopping effort.

The most severe landing stop brake kinetic energy absorption is required to be substantiated per § 25.735(f)(3). Return landing situations are applicable to this requirement.

Transport airplane manufacturers (otherwise referred to as OEM's – original equipment manufacturers) are required per § 25.1585(a) to furnish non-normal procedures for foreseeable failure conditions involving the use of special systems or the alternative use of regular systems and emergency procedures in which immediate and precise action by the crew may be expected to substantially reduce the risk of catastrophe. These operating procedures are to include specific procedures to mitigate the effects of the failure conditions, including performance adjustments applicable to immediate return or diversion landings.

The urgency of landing the airplane prescribed in the operating procedures will vary depending on the severity and consequence of the failure condition. Although the terminology is not standardized across the industry, Land ASAP ("land as soon as possible" or "land as soon as practicable") and Land ANSA ("land at the nearest suitable airport") are commonly used.

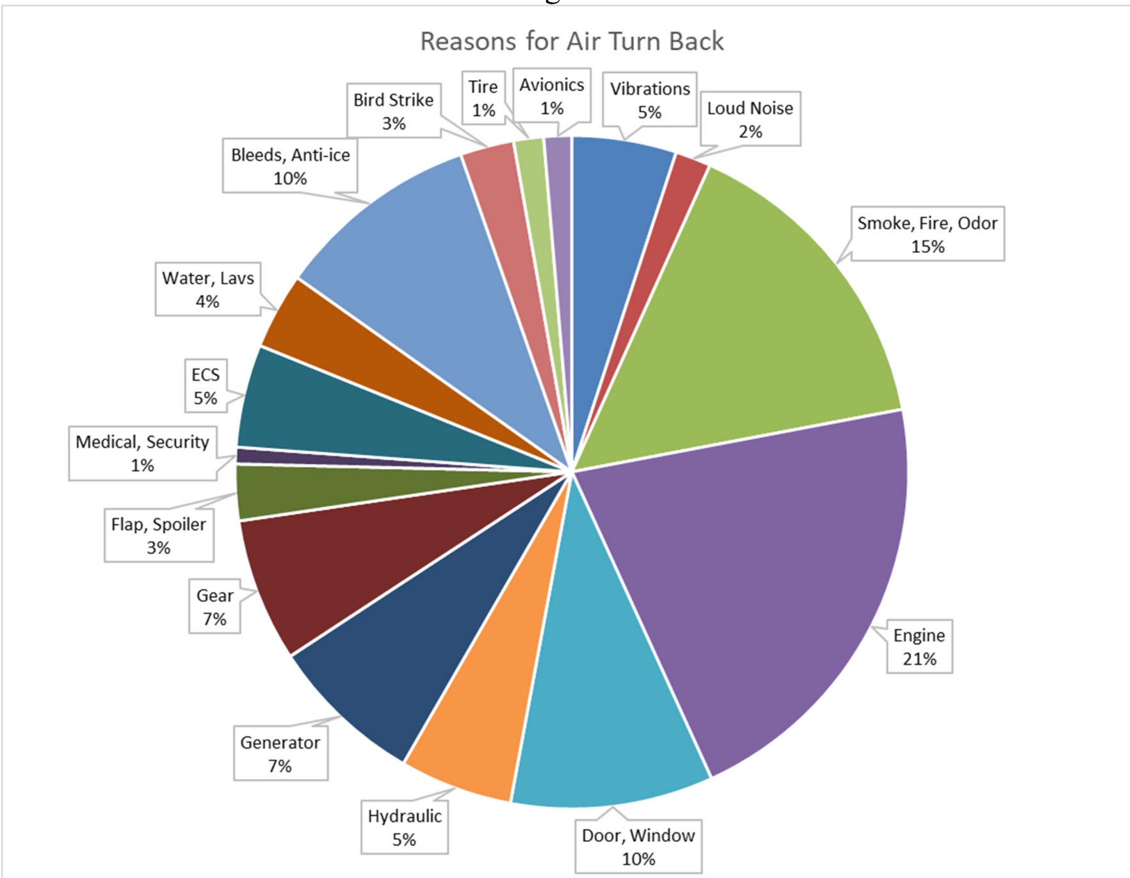
For procedures that specify landing at a suitable airport, it is expected that the flight crew would perform in-flight performance checks so that there is no reasonable risk of runway overrun or exceeding other landing performance limitations including maximum brake energy and maximum tires speed. In the discussions of this working group, it was understood that in urgent life-threatening situations requiring immediate landings, the flight crew may not have time to perform landing performance checks for suitability and would have to make the best use of the airplane capability at the nearest airport. It should also be noted that some projects only use Land ANSA terminology in their AFMs.

The definition of a suitable alternate aerodrome from ICAO Annex 6 is:

> *A suitable alternate aerodrome is an adequate aerodrome where, for the anticipated time of use, weather reports, or forecasts, or any combination thereof, indicate that the weather conditions will be at or above the required aerodrome operating minima, and the runway surface condition reports indicate that a safe landing will be possible.*

Fleet history has shown that immediate return or diversion landing risks can be mitigated with operating procedures and the vast majority of events result in landings that have minor or no safety effect on the airplane or occupants. "Air turn back" is common terminology used in flight reports and includes both immediate return and diversion landings. Figure 1 summarizes the results of a fleet study of 23 years of operations (approximately 11.5 million flights) of a large twin engine commercial airplane type. This study identified approximately 1,700 air turn back events. The data were collected for events with system-related reasons for air turn back and were not focused on reporting events with fully functioning airplane systems. Because the data were collected from safety event logs and reports without a structured format, only general conclusions could be made.

Figure 1



It should be noted from Figure 1 that most of the reasons for air turn back had no effect on landing performance. The vast majority of events reviewed in the fleet study above could be categorized as "land at the nearest suitable airport" or were even less urgent in nature and only a few of the air turn back events were identified as urgent enough to require immediate landing.

The airplane type in the study was equipped with a fuel jettisoning system and that system was identified as being used in about 5% of the events. It should be noted that the use of fuel jettisoning during these air turn back events may be under-reported because of the unformatted source of the information. Approximately 5% of the landings in the study were identified as overweight (above maximum landing weight), although that may also have been under-reported because of the source.

In a review of industry events, the FTHWG did not identify any examples of immediate overweight landings with catastrophic consequences resulting from performance deficiencies. However, there were several return landing events with severe failures and concerns that were identified and studied by the group. The working group excluded events from the scope of this topic where the airplane was not able to continue safe flight, or the outcome was not linked to the approach and landing maneuver.

On December 5, 2013 a Boeing 767-300 aircraft operated by Delta Airlines took off from the Madrid-Barajas Airport and experienced a tire blowout which caused damage to the wing and two of three hydraulic systems. The crew elected to land 48,000 lb overweight 23 minutes after takeoff using flaps 20 per the operating procedures for that failure condition. The airplane was equipped with a fuel jettisoning system, although it was not used in the relatively brief flight time. Because the damage to the hydraulics reduced the braking capability, affected the nosewheel steering, and disabled the thrust reverser on one engine, the airplane experienced a runway excursion. There was a runway excursion, but there were no fatalities or injuries in the event.

This event highlights the concern of potential runway excursions due to system failures that affect landing performance and the potential to reduced risk of occurrence with additional design considerations.

On June 17th, 2012 an Airbus A320 operated by JetBlue took off from Las Vegas and experienced a failure soon after takeoff that led to loss of two hydraulic systems which affected the flaps. After appropriate checklists, the crew was able to recover one of the failed hydraulic systems. The failure of one hydraulic system, however, affected the flight controls, braking and nosewheel steering systems. Due to the system malfunctions and the inability to raise the landing gear in the event of a go-around, the flight crew decided to remain in the holding pattern to burn fuel and reduce aircraft weight below the maximum landing weight of 142,200 pounds. The airplane landed 3 hours 35 minutes after takeoff and stopped on the runway.

This event highlights the concern that failures affecting landing performance could potentially lead to long-duration delays to landing. For this particular event, the crew could have decided to land sooner, as a Las Vegas runway was suitable (long enough, and further mitigated after recovery of one hydraulic system) for the aircraft to land safely, but they decided to remain in the vicinity and further mitigate the situation before landing.

On February 15th, 2017 a Bombardier CRJ-700 operated by PSA Airlines out of Charlotte, NC hit a deer on takeoff, damaging the wing leading edge and causing a fuel leak. The airplane returned and landed 30 minutes after departure without further incident.

Although this event involved damage difficult to anticipate when designing airplane return landing performance capability, it highlights the need for non-normal procedures and the capability to land overweight.

Airplanes rely primarily on aerodynamic design (including optimized flap configurations) and sufficient go-around thrust to show compliance with § 25.1001(a). However, if the immediate return climb performance does not fulfill the required gradient across the entire takeoff envelope, a limit on the computed takeoff weight may be employed to show compliance with § 25.1001(a). Airplanes are sometimes designed with fuel jettisoning systems to mitigate these limitations, but may also require takeoff weight limitations to show compliance because jettisoning may not be available in all situations. The amount of fuel available to jettison on a given flight is dependent on fuel loading, gross weight, temperature, altitude, and fuel system design. As part of the certification, the flow rate of the jettisoning system must be demonstrated by flight testing as prescribed in § 25.1001(c),(d).

OEM's primarily use analytical methods to show the return landing performance capability for the other concerns expressed in the FAA issue paper, e.g. landing distance, brake energy, tire speed, and margin to flap placard limit speeds. These analyses require numerous assumptions, and their complexity and magnitude has grown over time to become a considerable burden for some OEMs. Other OEMs have taken a more probabilistic approach, referencing § 25.1309 to show that most failure cases should not require an "immediate" return landing and thus are out of the scope of the performance analysis for showing compliance to § 25.1001(a),(b) in accordance with the issue paper.

Additional workload is required by the OEMs for any production design changes that affect the takeoff, landing, and climb performance (e.g. new thrust ratings). These changes must be evaluated and in some cases require new showing of compliance for return landing capability.

As part of the various telecon discussions/meetings, various documents were reviewed and discussed, including:

1. FAA issue paper – Return Landing Capability

2. Preamble to 14 CFR Part 25 [Docket No. 8563; Notice 67-51] Fuel Jettisoning Systems For Transport Category Airplanes
http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgNPRM.nsf/0/a1d19b4635d1266285256923006380b0!OpenDocument&ExpandSection=6#_Section6

A. What is the underlying safety issue addressed by the CS/FAR?

The primary safety concerns included the potentially catastrophic effects of events or failure conditions occurring soon after takeoff resulting in an overweight landing or missed approach.

- The excess weight and speed of immediate return landings could result in runway excursions, exceedance of maximum tire speed rating, or exceedance of maximum brake energy capability.
- Increased approach speed for overweight landings with insufficient margin relative to flap placard limit speeds or flap load relief operation speeds could lead to loss of control.

Additionally, there was a concern that an undefined extension of flight after encountering failures soon after takeoff would increase the risk to the potential next failure.

- Prolonged flight with certain system failures, or combinations of failures could have potentially catastrophic effects not fully addressed in existing requirements because there is no prescribed flight time limit for this situation.
- Prolonged exposure to degraded airplane systems with controllability or handling problems is a concern.

Both exposures must be balanced with the probability of the systems' failures that could lead to a catastrophic scenario and the handling qualities of the airplane with these systems failed.

B. What is the task?

Refer to Attachment 20A Work Plan per the ARAC Tasking from Federal Register.

C. Why is this task needed?

TCCA, FAA, ANAC and EASA standards and guidance do not consistently address the identified safety concerns and the range of compliance standards and methods of compliance has created an uneven playing field across the industry. The task is needed to harmonize the various agencies' requirements and guidance material on fuel jettisoning and return landing capability.

Some OEM's have imposed AFM dispatch weight limitations as part of this compliance while others have not. The working group identified inconsistencies in the application of § 25.1309(b) and the selection of which types of failures should be considered to require an immediate return, as well as inconsistency in whether the immediate return landing must be safely completed on the same runway as that used for take-off in dry and wet runway conditions. Most, but not all manufacturers have been required to show immediate return landing capability using an issue paper. These inconsistences in what has been required for certification have resulted in an uneven playing field.

There have been flights with system failures and degraded flight controls occurring soon after takeoff that required mitigating procedures and the crew chose to continue the mission for an extended duration to reduce the landing weight or to find a more suitable runway for landing. The existing Part 25 requirements do not ensure that airplanes are designed with the capability of landing within a set period of time following a failure soon after takeoff to minimize exposure to degraded systems affecting flying qualities and potential additional failures.

Landing runway excursions are a potential consequence of immediate return or diversion landings. Although runway excursions related to immediate return landings are extremely rare in the fleet history of current airplane designs, requirements for future designs should address the potential failures and other events that can lead to this type of hazard.

D. Who has worked the task?

This task has been worked by the Topic 20 sub-team of specialists on Performance and Handling Qualities from the following organizations:

- Certification agencies
    - European Aviation Safety Agency (EASA)
    - Federal Aviation Administration (FAA)
    - National Civil Aviation Agency of Brazil (ANAC)
    - Transport Canada Certification Agency (TCCA)
- Airplane manufacturers
    - Airbus
    - Boeing
    - Bombardier
    - Dassault
    - Embraer
    - Gulfstream
    - Textron Aviation
- Airlines
    - Norwegian Airlines
- Labor Unions
    - Air Lines Pilots Association (ALPA)

E. Any relation with other topics?

No

Historical Information

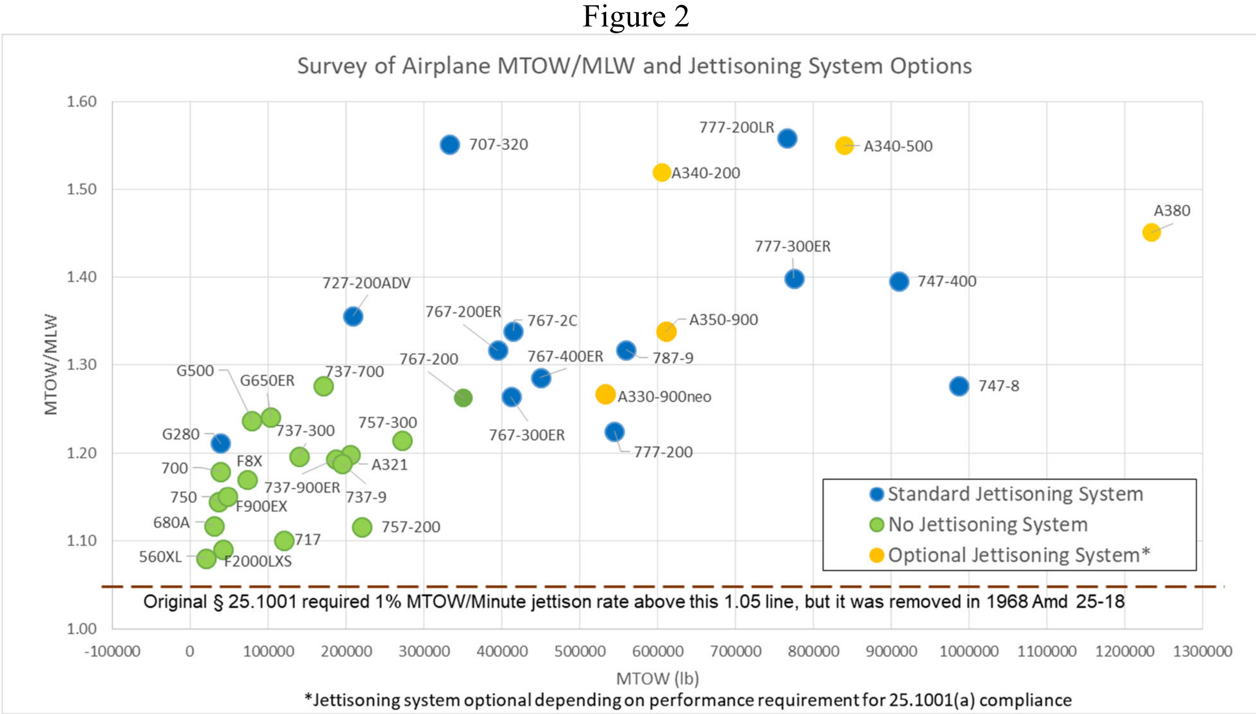
This working group tasking was the first attempt to harmonize the return landing capability regulations and associated guidance in the airplane industry.

The original intent of § 25.1001(a),(b) in 1965 was to address heavy-weight immediate return landing situations by requiring a fuel jettisoning system. The FAA's stated philosophy at the time was that having a jettisoning system available would enhance safety regardless of the specific requirements. Of primary concern were return landing scenarios above MLW where excessive hold times with severe system failures would be required before landing (to reduce weight by burning fuel).

The original § 25.1001 rule required a jettisoning system when the ratio of MTOW/MLW was greater than 1.05 (see Figure 2). Early jet transports were not required to have the structural capability of modern airplane designs for overweight landings and engines had relatively low takeoff thrust capability. The rule was amended relatively quickly in 1968 to remove the MTOW/MLW ratio requirement and replace it with the approach and landing climb requirements which still form the basis of the current rule. There were other climb requirements studied for this amendment, but simply referencing § 25.119 and § 25.121(d) and defining 15 minutes as the time period for an immediate return landing was seen as sufficient. The hazards associated with exceeding landing distance, brake energy and tire speed limits in an immediate return landing were also discussed at the time, but analysis of several models by OEMs showed that these factors would not be limiting (for the operations envisioned at the time). The FAA introduced guidance material in AC 25-7A in 1998 for § 25.1001 specifying that airplanes should also be investigated for other elements (other than climb performance) that may limit their ability to safely accomplish an immediate return landing, including exceedance of certification limits for brake energy, tire speed and landing distance. That guidance has remained unchanged through AC 25-7D released in 2018.

Figure 2 shows the ratio of maximum takeoff weight to maximum landing weight (MTOW/MLW) as a function of MTOW for a wide range of Part 25 airplane models. Most single aisle (smaller) commercial airplanes shown do not have jettisoning systems, while most of the larger models do have a system either as standard or available as an option. Most Part 25 business airplanes currently in production do not have fuel jettisoning systems with one exception shown in Figure 2.

Figure 2



In the late 1980's a return landing concern was raised by the FAA for the 767-200ER and 767-300 increased gross weight derivatives. Since these derivatives could meet the climb requirements of § 25.1001(a) despite their increased takeoff weight, they were designed without a fuel jettisoning system like the parent 767-200 model. In 1988 Boeing was compelled by the FAA to add a jettisoning system to 767 models with MTOW exceeding 360,000 lb, which applied as a retrofit of airplanes that had already been built.

The FAA initiated return landing issue papers in the 1990s to address growing concerns that MTOW (especially for twin-engine airplanes) had increased so much since § 25.1001 was originally drafted that it was no longer sufficient to consider only climb requirements to ensure safe return landing capability.

A generic return landing issue paper was drafted it the late 1980s and applied to Boeing (777) and Airbus in the early 1990s. It was subsequently applied to most new Part 25 airplane models and major derivatives.

The return landing issue papers introduced additional compliance subjects including but not limited to:

- Exceedance of certificated maximum brake energies;
- Exceedance of tire speed limits;
- Controllability (e.g., hydraulic and/or flight control system failures);
- Margins to flap placard limit speeds, or flap load relief operation speeds in turbulent air;
- Landing distances (including wet runway, brake failures, spoiler failures, etc.).

These additional subjects have historically been addressed in the basic airplane design and operating procedures, but some models have required flight manual limitations implemented specifically for return landing compliance. Compliance using takeoff weight limitation was not anticipated by the regulators to the extent it has been implemented, sometimes in lieu of installing a fuel jettisoning system. Some of the AFM limitations implemented by OEM's address airplane loading configurations and areas of the flight envelope in which fuel is not available to jettison, even if there is a system installed. For example, high-payload, short-range missions can be return-landing climb limited for takeoff at high altitude airports as there may not be enough fuel loaded to reduce landing weight by jettisoning.

A. What are the current regulatory and guidance material CS 25 and FAR 25?

Current regulatory and guidance material are defined in

- FAA : 25.1001(a),(b) and Section 25.1 of Advisory Circular (AC) 25-7D, Paragraph 43(a) of Advisory Circular (AC) 25-22
- EASA : (CS) 25.1001(a),(b)

B. What, if any, are the differences in the existing regulatory and guidance material CS 25 and FAR 25?

There are no regulatory differences in § 25.1001(a),(b) between the FAA, EASA, TCCA and ANAC.

The following significant difference was identified and was discussed throughout the various meetings (refer to "Background" paragraph above for more details):

EASA does not provide guidance (AMC) material for § 25.1001 as provided by the FAA in AC 25-7D Paragraph 25.1.

C. What are the existing CRIs/IPs (SC and MoC)?

The existing CRIs/IPs are defined in:

- FAA: Return Landing Issue Paper
- EASA: No equivalent CRI for return landing capability has been issued

- TCCA : Transport Canada Issue Paper Immediate Return to Land Capability
- ANAC: ANAC Return Landing Capability FCARs

D. What, if any, are the differences in the Special Conditions (CRIs/IPs) (SC and MoC) and what do these differences result in?

The conditions to be addressed include but may not be limited to:

a. Exceedance of certificated maximum brake energies,
b. Exceedance of tire speed limits,
c. Reduced controllability (e.g. due to hydraulic system or flight control system failures),
d. Airspeed margins to flap placard limiting speeds in turbulent air,
e. Procedures for go-around and landing, and
f. Landing distances (including wet runway).

The lack of similar EASA CRIs to the return landing issue papers from other regulatory agencies is a difference. EASA operators have questioned the need to limit takeoff weight to allow immediate return landing to the departure runway from a regulatory jurisdiction viewpoint.

While ANAC has a FCAR similar to the FAA issue paper, there have been significant discussions on which failures would require an immediate return for landing. One point of disagreement in older programs was that ANAC did not require one-engine-inoperative accountability for immediate return landing compliance, while the FAA did.

TCCA requires specific flight demonstrations for:

a. Takeoff at or above maximum structural takeoff weight, followed by All Engines Operating (AEO) go-around at 200 ft, followed by AEO landing, and
b. Takeoff at or above maximum structural takeoff weight, followed by One Engine Inoperative (OEI) landing.

There have been some specific differences identified in the manner of compliance across the industry:

- The Amdt. 25-121 icing requirements became an issue because they apply to the §§ 25.119 and 25.121(d) climb requirements referenced in § 25.1001. Because of this, some applicants have applied constraining AFM limitations on takeoff weight in icing conditions to comply with approach and landing climb performance with the thrust effects from the ice protection system and drag effects of ice accretion. These limitations were not consistently applied across the industry nor was there consistent guidance.
- Some applicants with designs not including fuel jettisoning have applied AFM limitations on takeoff weight for immediate return landing distance (on wet runways specifically) to account for potentially urgent emergency conditions while others have taken credit for operating procedures that instruct the flight crew to further mitigate the situation by delaying landing to reduce weight or find a more suitable runway.
- Some applicants have been required to consider certain system failures that are remote or extremely remote as the cause of immediate return landing situations, but other applicants have been able to

rationalize that these types of failures, when combined with conditional factors are extremely improbable, and do not need to be considered immediate.

Consensus

The FTHWG reached consensus on a number of concepts as stated below.

- The FTHWG agreed that the conditions for go-around climb requirements § 25.119 and § 25.121(d) referenced in § 25.1001(a),(b) were intended to address the entire takeoff gross weight envelope for an immediate return to the departure runway up to the maximum permitted for takeoff throughout the approved temperature and altitude envelope. The FTHWG agreed that clarification should be added to 25.1001(a) stating that it is also acceptable to consider the use of emergency (non-normal) approach and landing flap configurations and speeds, if those procedures are applicable.
- The FTHWG believed that when the icing requirements were introduced in Amdt. 25-121 affecting § 25.119 and § 25.121(d), the performance effects on immediate return go-around climb were not considered. Because the scenario combines a remote event, or failure, to initiate the return to land, a limited timeframe (immediate return), and an independent reason not to land and instead perform a go-around, the FTHWG believed that it was an undue burden to reduce AFM takeoff performance for potential icing conditions. As such, it was agreed that only non-icing conditions need to be evaluated for design of immediate return landing capability.
- The FTHWG reviewed fleet data and concluded that a small minority of events (failures and other causes) require immediate or "urgent" return landings, but most situations allow time to further mitigate the potential hazard in flight. It was agreed that design criteria for immediate return landings should be focused on events and failures that prompt urgent action, including single-engine failure cases. It was understood that the urgency of immediate return landings may not allow the flight crew to divert to a more suitable runway, so the airplane should be designed to land immediately in these cases.
- Fleet data show that delays to reduce weight and diversions to more suitable runways can effectively mitigate the hazards in most situations. Since OEM's furnish procedures for failures that could affect the landing performance, it was agreed that these events may not need to be considered as the cause of immediate landings, other than failure of an engine.
- There was a proposal that immediate return landing requirements not be defined as returning to the departure runway, which would allow consideration of nearby alternate landing runways (e.g. within 20 miles) that may be more suitable (e.g. longer). This approach would rely on operational checks before takeoff to ensure that there would always be a suitable nearby immediate alternate if the departure runway was not long enough for a one-engine inoperative landing. The FTHWG decided that the design analysis be based on returning to the departure runway was preferable and would reduce the complexity of the analysis. This design approach does not limit or preclude flight crews in service from diverting to a more suitable nearby alternate at their discretion. There may be specific situations where an applicant may choose to request consideration of a nearby alternate as an equivalent level of safety instead of making significant design changes for a limited set of operations.
- The FAA clarified a regulatory concern that an extended flight delay in a degraded state would expose the airplane to unacceptable additional risk. The concern was that airplanes may have to hold for multiple hours or divert to a distant location to find a more suitable landing runway. There was

an extended discussion questioning why this concern was not satisfied by existing requirements for continued safe flight and landing, § 25.1309(b), or ETOPS. It was eventually agreed in the FTHWG that some form of design requirement was needed, but it was deemed inappropriate to include it in § 25.1001, which was intended to focus on fuel jettisoning systems.

- The FTHWG decided that failures occurring soon after takeoff that cause a degraded state of flight control and adversely affect handling, but do not require immediate landing per procedure, should have a design criteria to limit the exposure time to the next critical failure. The FTHWG studied system failure cases that affect landing performance and compared the resulting landing distance for various airplane types to worldwide airport runways within 60 minutes of short runways with frequent operations. In all but a few remote airports, an 8,000 ft runway can be reached within 60 minutes of departure from a shorter runway, assuming the airplane can fly approximately 350 nm in that time period. It was decided that a diversion landing runway length of 8,000 ft would be an appropriate assumption, however applicants may propose a longer landing runway length if it represents the expected operations of the airplane. For example, a 10,000 ft diversion landing runway assumption might be shown to be appropriate for the expected operations of a large widebody airplane. It was decided that 60 minutes should be the default diversion time, but in the cases of extremely remote failures a diversion time up to 90 minutes would be appropriate to allow consideration of a more distant or longer landing runway.
- In the discussion of the 60 minute and 90 minute diversion times, it was noted that flap-drive failures when the flaps are "jammed" in an extended position may not result in degraded flight control, or adverse handling effects, but it was agreed that these design cases should be subject to the time limits because of the potential for in-flight icing during extended flight. It was agreed that the 60 to 90 minute diversion time, assuming the flight crew would avoid flying into icing conditions, was adequate mitigation, as opposed to allowing longer diversion times with the flaps extended and having to account for the potential effects of ice on controllability.
- The guidance in AC 25-7D paragraph 25.1.1.4 is proposed to be clarified because it was unclear to the working group which go-around configuration and procedures it was applicable to and what to do with the information once it is determined. There was discussion of re-locating this guidance to address § 25.101(g) go-around performance, however, the consensus was that the guidance was intended for overweight return landing situations and should remain in paragraph 25.

Majority Positions:

- The majority of the FTHWG agreed that the hazards identified in the issue papers related to tire speed limits, brake energy limits, flap speed limits and landing distance were intended to address overweight landing conditions and were not intended to limit AFM takeoff performance for immediate return or diversion landings at or below maximum landing weight. This position reflects the original intent of § 25.1001(a),(b) to ensure safe return landing capability when the permissible takeoff weight significantly exceeds the design maximum landing weight (refer to discussion in Background Section F – Historical Information). The requirements in 25.127(a) and 25.127(b) with guidance in paragraph 4.x.5 of AC 25-7D limit the design analyses to cases with landings above maximum landing weight (MLW).
- The majority of the FTHWG agreed that takeoff runways below 6,000 ft in length do not need to be considered in the design analysis for immediate return landing capability. Several of the manufacturers showed that there was a potential for operational takeoff limitations below this relatively short runway length, however these limitations would occur in unlikely corners of the

envelope for most designs, are mitigated with operational procedures, and are not the primary focus of this safety issue.

Dissent

ANAC dissent on MLW and 6,000 ft runway length cutoff of design analysis for immediate return landing:

> *ANAC does not agree with the proposed limitations to the immediate return landing analysis on 25.127. The proposed 25.127(a) rule text itself would restrict the analysis to "weights above maximum landing weight up to maximum takeoff weights", while 25.127(b) has the same restriction on the guidance material. ANAC agrees that 14 CFR 25.1001 was originally designed to address projects with MTOW and MLW significantly different. However, the safety risk represented by an airplane not being able to immediately return to the takeoff runway does not cease to exist at MLW. As described in this report, some of the OEMs in the FTHWG group provided a comparison of landing and takeoff distances for different conditions. These preliminary studies pointed to safety risk exposures, i.e. landing distances superior to takeoff distances, in some conditions. The proposed rule applicability limitation to MLW and runway lengths superior to 6,000ft (this last restriction proposed on the guidance material) would not prevent projects with exposure to this safety risk. ANAC understands that airworthiness regulations may not be designed to address all operational scenarios. The FTHWG followed this approach in the proposed 25.127(b) runway length criteria and its small exposure presented in Figure 3 of this report. However, ANAC would need additional support data to agree with the other limitations proposed to 25.127. There is ANAC concern with the fact that Brazil has at least 6 airports other than SBRJ with runways shorter than 6,000ft and daily regular flights operated by single-aisle jets.*

Response to ANAC dissent:

> The scope of the design analysis for immediate return landings in the proposed 25.127(a) and diversion landings in 25.127(b) was intentionally focused on the stated safety concern of overweight landings and the criteria were defined to avoid making a rule that would primarily be met with operational takeoff limitations. While there is potential exposure of wet runway overrun for immediate landing weights below MLW or on runways shorter than 6,000 ft, it is believed to be a relatively small number of operations, and the risk in these conditions has not resulted in a systemic problem in the existing fleets. Including weights below MLW in the design analysis would not necessarily result in design changes, such as adding or increasing jettisoning capability. It would be more likely to result in operational takeoff limitations designed to avoid exposure to these limited conditions. A mitigating factor that was considered in the group decision to exclude runways less than 6,000 ft long, was to not allow certification analysis credit for immediately diverting to a more suitable nearby runway. Flight crews have onboard performance information to decide if they should risk overrun returning to the departure runway or look for a more suitable runway. Further studies of single-aisle jets and turboprops on relatively short runways may be able to define a more applicable minimum runway length for this design analysis, but it is unclear if this, or expanding the envelope below MLW, would improve the overall level of safety beyond the proposed criteria.

Recommendation

The FTHWG was able to complete the technical discussions needed to define a complete consensus or majority position on all the identified issues.

The FTHWG recommends that ANAC, EASA, FAA, and TCCA revise their regulations and guidance material to include the proposed immediate return or diversion landing capability regulatory and guidance material presented in Attachment 20B.

A. Rulemaking

1. What is the proposed action?

The FTHWG recommends changes to 14 CFR 25.1001 and Paragraph 25.1 of AC 25-7D, and Paragraph 43 of AC 25-22. It is also recommended that a new regulation, Section 25.127 be added to address immediate return or diversion landing capability. This new regulation is proposed to be introduced in Subpart B along with new guidance material in Chapter 4 (Flight: Performance) of AC 25-7D

2. What should the harmonized standard be?

With the proposed action (see Attachment 20B), full harmonization of immediate return landing capability and a time-limited diversion landing capability can be achieved across the regulatory agencies.

3. How does this proposed standard address the underlying safety issue (identified under #1)?

The proposed design standards directly address the potential hazards associated with overweight immediate return or diversion landings exceeding the certification limits of maximum brake energy, tire speed, controllability, margin to flap placard limit speeds and flap load relief operations in turbulent air. Also, there is a requirement to land safely within the available stopping distance.

The existing go-around climb requirements are retained, with clarification regarding in-flight icing conditions and engine-inoperative procedures.

A requirement was added that ensures Part 25 airplanes are designed to land within a limited time period for certain failure cases with degraded airplane systems adversely affecting handling and to limit exposure to aggravated risk.

4. Relative to the current FAR, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.

The level of safety will increase by directly addressing the potential hazards associated with overweight immediate return or diversion landings exceeding the certification limits of maximum brake energy, tire speed, controllability, margin to flap placard limit speeds, and flap load relief operations in turbulent air. The addition of a requirement to ensure airplanes are designed to land in a limited time for certain failures after takeoff will limit exposure to aggravated risk situations.

5. **Relative to current industry practice, does the proposed standard increase, decrease, or maintain the same level of safety? Explain.**

The level of safety will be maintained for those currently satisfying the FAA issue paper with some potential increase in safety due to the addition of a requirement to ensure airplanes are designed to land in a limited time after takeoff for certain failures to limit exposure to aggravated risk situations. The level of safety will be increased for applicants who have not been required to use the FAA means of compliance issue papers or similar regulatory material used by other certification agencies.

6. **Who would be affected by the proposed change?**

Any applicant certifying a new or significantly changed airplane design will need to consider these requirements per the changed product rule process. There may be system design changes required to ensure the ability to land at a suitable runway within 60-90 minutes with failure conditions that cause a degraded state of flight control and adversely affect handling. Regulatory agencies will have harmonization activities to be completed.

7. **Does the proposed standard affect other HWG's and what is the result of any consultation with other HWGs?**

The guidance in AC 25-22 will be affected and should be considered by the Systems Harmonization Working Group.

B. Advisory Material

1. **Is existing FAA advisory material adequate? If not, what advisory material should be adopted?**

The FTHWG believes that the current FAA advisory material is not adequate. Proposed changes to advisory material are attached (see Attachment 20B).

2. **To ensure harmonization, what current advisory material (e.g., ACJ, AMJ, AC, and policy letters) needs to be included in the rule text or preamble?**

The intent is to harmonize EASA CS 25 AMC, FAA AC 25-7D, ANAC and TCCA guidance. The goal is to discontinue the use of Return Landing Capability issue papers in future certifications, and to introduce the proposed advisory material along with the proposed regulatory changes.

Economics

A. What is the cost impact of complying with the proposed standard?

Some airplane designs may require more restrictive AFM takeoff weight limitations while some may have less because of the proposal. A potential impact is the cost of more redundancy in certain systems in order to maintain near-normal handling qualities and landing performance, and there is the potential that a fuel jettisoning system would be needed to meet the new requirement relative to existing standards.

It is expected that there will be reduced cost for multi-agency certification resulting from the harmonized standards and the elimination of issue papers on this subject. Some OEMs who have not had a return-landing issue paper in the past will incur certification costs not previously required. OEMs who have had issue papers may benefit from clear requirements and guidance which will allow earlier evaluation of systems in the design cycle and less burden showing compliance after the systems have been designed.

B. Does the HWG want to review the draft NPRM prior to publication in the Federal Register?

Yes

ICAO Standards
How does the proposed standard compare to the current ICAO standard?

There are no current ICAO Annex 8 standards regarding Airworthiness of Aircraft for Large Aeroplanes that specifically address design for return landing capability.

Attachment 20A: Topic 20 Work Plan – Return to Land

1. What is the task?
The task is to develop a harmonized regulatory basis and guidance material for return to land scenarios. - Review existing regulatory and guidance material (refer §4 below) - Review OEM's best practices, methodology and criteria used on past certifications.
2. Who will work the task?
The Flight Test Harmonization Working Group (FTHWG) will have primary responsibility for this task. Consideration will be given for consultation with SME's representing fuel systems.
3. Why is this task needed? (Background information)
The topic is not harmonized since FAA, TCCA and ANAC have applied return to land issue papers with specific performance and handling criteria, but notably, EASA has not. The implementation of 14 CFR Amd 25-121 icing regulations have resulted in confusion for OEM's in what is required for RTL compliance with respect to § 25.119 and § 25.121 and further clarification is needed. Consultation of OEM's methodologies and best practices in regard to performance and handling qualities criteria will assist in harmonization of reasonable and practical material guidance for return to land scenarios.
4. References (existing regulatory and guidance material, including special conditions, CRIs, etc.)
FAA issue papers have applied to Airbus, Boeing, Dassault, Embraer, and Gulfstream TCCA issue paper applied to Bombardier ANAC issue paper applied to Embraer models
5. Working method
It is envisioned that 1-2 face-to-face meetings over a period of 30 months will be needed to facilitate the discussion needed to complete these tasks. Telecons and electronic correspondence will be used to the maximum extent possible, in particular, between face-to face meetings to ensure that progress is maintained.
6. Preliminary schedule (How long?)
Recommendations to Transport Airplanes and Engines Subcommittee within 12 months of the initiation of work on these tasks.
7. Regulations/guidance affected
14 CFR 25.733, 25.735, 25.1001, 25.1301, 25.1309 AWM 525.733, 525.735, 525.1001, 525.1301[IP M-01], 525.1309[IP M-01] CS 25.1001
8. Additional information
Background:

The original intent of § 25.1001(a),(b) was to address heavy-weight return landing situations with the climb requirements in § 25.119 and § 25.121(d). The FAA's stated philosophy is that having jettison available enhances safety regardless of the specific requirements. A primary concern is return to land scenarios where excessive hold times are required to reduce landing weight.

In the late 1980's a RTL concern was raised by the FAA for the 767-200ER and -300 IGW derivatives because the 767-200 was originally designed without a fuel jettison system. In 1988 Boeing was compelled by the FAA to add a jettison system to 767s with MTOW > 360,000 lb, including a retrofit of airplanes that had already been built.

RTL issue papers in the 1990s originated from concern that the MTOW (especially for twin-engine airplanes) had increased so much since § 25.1001 was drafted in the 1960s, that it was no longer sufficient to consider only climb limits to ensure safe RTL capability.

A generic RTL issue paper was drafted it the late 1980s and applied to the Boeing (777) and Airbus in the early 1990s. It was subsequently applied to all new models and major derivatives.

The RTL issue papers introduced additional compliance subjects including but not limited to:
- Exceedance of certificated maximum brake energies;
- Exceedance of tire speed limits;
- Controllability (e.g., hydraulic and/or flight control system failures);
- Margins to flap placard, or load relief operation speeds in turbulent air;
- Climb capability, engine-inoperative procedures; and
- Landing distances (including wet runway, anti-skid off, spoiler failures, etc.).

In many cases, these additional subjects are addressed in the basic design of the airplane and operating procedures, but there have been design changes, new operating procedures, and flight manual limitations implemented for return landing compliance.

While airplanes without fuel jettison rely heavily on operating procedures to show compliance, airplanes with fuel jettison systems still have challenges showing compliance to all of the subjects across the flight envelope. Also, the amount of fuel available to jettison is highly dependent on many parameters including gross weight, CG, airplane zero fuel weight (with payload), and fuel system design. Additionally, the jettison systems must demonstrate its rate capability by flight testing.

Other than the jettison flight test, OEM's use analytical means to show compliance to RTL. There are numerous assumptions required for these analyses and the complexity and magnitude of the analyses has become a considerable burden for some OEMs. Production design changes that affect the takeoff, landing, and climb performance (e.g. thrust ratings) must be evaluated and can require considerable analysis or even design or procedural changes to show RTL compliance.

A study of the 777 fleet history shows that most immediate return and diversion landings are due to non-system failures and a very small percentage are due to system failures that adversely affect landing performance.

Attachment 20B - Proposed Standards and Rationale

This section provides the recommended 14 CFR 25 rule modifications, the specific topics that associated advisory material should address, and the rationale for the standard.

Proposed verbiage for the regulation or current regulation verbiage is in the first column, while the second column documents the recommended advisory material supporting the regulation. A rationale and discussion follows each section for the recommendations or any dissent on the specific sections. Note that revised and new proposed regulations will be in red italics. Black text indicates existing regulation or advisory material verbiage.

The following proposal was based on introducing a new 14 CFR 25 Subpart B regulation, § 25.127. It was felt that separating the immediate return or diversion landing performance requirements into a new stand-alone regulation was the most appropriate means to implement the new requirements while leaving the return landing climb requirements intact in § 25.1001. For this solution to be complete, significant information was included in the advisory material. For Part 25 flight test and compliance with airplane performance related regulations, this is in AC 25-7D. For fuel systems this advisory material is in AC 25-22.

As in the previous amendments of § 25.1001, these requirements are intended to be used as standards to improve the safety of airplane designs. As airplane takeoff performance capabilities have improved, the immediate return and diversion landing capability has not necessarily been improved in direct proportion. AFM limitations on takeoff performance have been employed and may be continued by most OEMs when it is impractical or uneconomic to address the exposures by design.

(Proposed changes are identified in *red italic characters*):

Regulation	Guidance
Sec. 25.1001 Fuel jettisoning system. (a) A fuel jettisoning system must be installed on each airplane unless it is shown that the airplane meets the *(non-icing) minimum* climb *gradient* requirements of Secs. 25.119*(a)* and 25.121(d)*(2)(i)* at maximum takeoff weight, less the actual or computed weight of fuel necessary for a 15-minute flight comprised of a takeoff, *return to land, approach, and initiation of* go-around~~, and landing~~ at the airport of departure with the airplane configuration, speed, power, and thrust the same as that used in meeting the applicable takeoff, approach, and landing climb performance requirements of this Part. *It is also acceptable to consider the use of emergency (non-normal) approach and landing flap configurations and speeds, if those procedures are applicable.*	AC 25-7D 25.1 Fuel Jettisoning System—§ 25.1001. 25.1.1 Explanation. 25.1.1.1 Section 25.1001(a) prescribes the conditions governing the need for installation of fuel jettisoning systems *to meet minimum climb gradient capability*; if an airplane can meet the *(non-icing)* climb *gradient* requirements of §§ 25.119*(a)* and 25.121*(d)(2)(i)*, at the weight existing after a 15-minute flight consisting of a maximum weight takeoff *(or performance limited weight)* and immediate return *with a go-around* ~~landing~~, a fuel jettisoning system is not required. Credit is given for the actual or computed weight of fuel consumed in the 15-minute flight using the airplane configurations, power or thrust settings, and speeds appropriate to each flight segment.

Regulation	Guidance
(b) If a fuel jettisoning system is required it must be capable of jettisoning enough fuel within 15 minutes, starting with the weight given in paragraph (a) of this section, to enable the airplane to meet the *(non-icing) minimum* climb *gradient* requirements of Secs. 25.119*(a)* and 25.121(d)*(2)(i)*, assuming that the fuel is jettisoned under the conditions, except weight, found least favorable during the flight tests prescribed in paragraph (c) of this section.	25.1.1.2 If a fuel jettisoning system is required, § 25.1001(b) prescribes the conditions that will determine the minimum flow rate of the system. Section 25.1001(b) requires the fuel jettisoning system to be capable of reducing the weight of the airplane, within 15 minutes of operation, from that specified in § 25.1001(a) to a weight at which the airplane will meet the *(non-icing)* climb *gradient* requirements of §§ 25.119*(a)* and 25.121(d)*(2)(i)*. Since the weight defined in § 25.1001(a) allows credit for a 15-minute fuel burn *(relative to a takeoff weight that may be performance limited)*, a literal interpretation of this rule would result in a 15-minute jettisoning period beginning after a 15-minute takeoff *and return flight, before* go-around~~*, and approach flight*~~. In application, the 15-minute jettisoning period will occur during a 30-minute flight in which weight reduction credit will be given for the fuel consumed and jettisoned. The airplane must be able to meet the specified climb *gradient* requirements at the weight existing at the end of this 30-minute flight. *25.1.1.3 There are other aspects of airplane design and operation besides fuel jettisoning that determine if an airplane can meet the climb gradient requirements referenced in § 25.1001(a),(b) including flap configuration, climb speeds, and operating procedures. Whether or not a fuel jettisoning system is installed, it may be determined that AFM takeoff weight limitations are necessary to meet the climb gradient requirements across the entire approved takeoff envelope.* ~~*25.1.1.3 Airplanes should also be investigated for other elements that may limit their ability to safely accomplish an immediate return landing without a fuel jettisoning system. Advances in wing design and propulsion technology have resulted in transport category airplane designs that can take off at weights considerably above their maximum landing weights. Many of these airplanes are capable of meeting the climb requirements of §§ 25.119 and 25.121(d), following a 15-minute flight, without a fuel jettisoning system. Some of these airplanes, however, may not be capable of landing without exceeding other certification limits such as maximum brake energy, landing distance, and tire speed. This is particularly true when non-normal procedures, implemented as a result of failures that have been shown to be foreseeable events, call for reduced flap settings and increases of as much as 30 knots, for a given weight, over speeds associated with the normal landing flap setting. Margins to flap placard limit speeds and flap load relief activation speeds should be established and maintained for non-normal configurations that may be used in immediate return landings.*~~ 25.1.1.4 An additional *return landing* consideration that is representative of actual operating conditions is the ability

Regulation	Guidance
	to perform a *missed-approach* go-around from field elevation ~~*with the flaps in the approach position and the landing gear down. Through compliance with § 25.1001(b), assurance will be obtained that the airplane can accomplish an all-engines-operating balked landing go-around, with normal landing flaps, followed by a one-engine-inoperative climb-out with approach flaps and landing gear up. However, non-normal procedures generally call for one-engine-inoperative landings to be made with the flaps in the position used to show compliance with the approach climb requirements of § 25.121(d).*~~ *in accordance with the procedures established in § 25.101(g)(h) for a one-engine-inoperative landing.*~~,~~ ~~i~~It should ~~therefore~~ be determined*, consistent with the applicable one-engine-inoperative landing and go-around procedures from the flight manual,* under what combinations of weight, altitude, and temperature the airplane can establish a positive rate-of-climb *with the landing gear extended and the remaining engine(s) at go-around power or thrust. If positive rate-of-climb cannot be achieved for otherwise allowable takeoff conditions, then appropriate mitigations should be put in place either through operational information or AFM limitations.* ~~*with one-engine-inoperative and the other operating at go-around power or thrust, with the flaps in the appropriate go-around position and the landing gear down.*~~
(c) Fuel jettisoning must be demonstrated beginning at maximum takeoff weight with flaps and landing gear up and in— (1) A power-off glide at 1.3 V_{SR1}; (2) A climb at the one-engine inoperative best rate-of-climb speed, with the critical engine inoperative and the remaining engines at maximum continuous power; and (3) Level flight at 1.3 V_{SR1}; if the results of the tests in the conditions specified in paragraphs (c)(1) and (2) of this section show that this condition could be critical. (d) During the flight tests prescribed in paragraph (c) of this section, it must be shown that-- (1) The fuel jettisoning system and its operation are free from fire hazard; (2) The fuel discharges clear of any part of the airplane; (3) Fuel or fumes do not enter any parts of the airplane; and (4) The jettisoning operation does not adversely affect the controllability of the airplane. (e) For reciprocating engine powered airplanes, means must be provided to prevent jettisoning the fuel in the tanks used for takeoff and landing below the level allowing 45 minutes flight at 75 percent maximum continuous power. However, if there is an auxiliary control independent of the main jettisoning control, the system may be designed to jettison the remaining fuel by means of the auxiliary jettisoning control. (f) For turbine engine powered airplanes, means must be	*§ 25.1.1.5 If a fuel jettisoning system is determined to be necessary per the requirements of § 25.1001(a), § 25.127, or other operational needs, the system must adhere to the applicable regulatory requirements of § 25.1001(c),(d),(e),(f),(g),(h),(i).*

Regulation	Guidance
provided to prevent jettisoning the fuel in the tanks used for takeoff and landing below the level allowing climb from sea level to 10,000 feet and thereafter allowing 45 minutes cruise at a speed for maximum range. However, if there is an auxiliary control independent of the main jettisoning control, the system may be designed to jettison the remaining fuel by means of the auxiliary jettisoning control. (g) The fuel jettisoning valve must be designed to allow flight personnel to close the valve during any part of the jettisoning operation. (h) Unless it is shown that using any means (including flaps, slots, and slats) for changing the airflow across or around the wings does not adversely affect fuel jettisoning, there must be a placard, adjacent to the jettisoning control, to warn flight crewmembers against jettisoning fuel while the means that change the airflow are being used. (i) The fuel jettisoning system must be designed so that any reasonably probable single malfunction in the system will not result in a hazardous condition due to unsymmetrical jettisoning of, or inability to jettison fuel. Amdt. 25-108, Eff. 12/26/2002	

Rationale

The working group discussed the scenario defined by the original climb requirements of § 25.1001 which consists of an urgent reason to return to land and a subsequent missed approach (approach climb) with one engine inoperative per § 25.121(d), or an all-engines-operating landing climb per § 25.119. Of prime concern would be an engine failure or shutdown causing an immediate return to the takeoff runway, which could then encounter a missed approach. This is an unlikely scenario, as the reason to immediately land would likely discourage the crew from performing a go-around, however, this scenario is foreseeable and should be considered. For 25.121(d) compliance, OEMs have historically had to consider both the case of an engine failure as the cause of the return landing and the case of a return landing for an independent reason where the engine fails at the start of the go-around maneuver following a normal all-engines landing approach. The most likely situation is to assume that the engine fails on takeoff or initial climb, and that the rest of the 15 minute flight (or 30 minute with fuel jettisoning) is performed with one engine inoperative. This means that the return flight, approach to land and go-around must follow the speeds and flaps setting of the single-engine procedure defined in the AFM. The FTHWG discussed that the second scenario, an engine failure at start of go-around after a missed all-engine landing approach, and that it was extremely unlikely, but would be within the normal operating envelope if it occurred. It was agreed to clarify in 25.1001(a) that it is also acceptable to consider the use of emergency (non-normal) approach and landing flap configurations and speeds, if those procedures are applicable. An example of this would be a non-normal overweight landing procedure which would prescribe alternate landing and go-around flaps and speeds for landings above MLW. This procedure would affect the return landing design analysis assumptions used to meet the 25.119(a) and 25.121(d)(2)(i) minimum climb gradient requirements.

When the icing requirements of Amendment 25-121 were implemented, the climb gradient requirements referenced in § 25.1001(a),(b) were affected. It is not believed that the Amendment 25-121 effort considered the effects of icing on an immediate return landing and the resulting impacts on takeoff dispatch performance. This group proposes changes to the regulation to remove reference to the icing effects on the climb requirements. It was felt that adding these icing conditions to an immediate return landing condition, which already assumed unlikely scenarios, was an unintended and burdensome requirement.

The guidance deleted from AC 25-7D § 25.1.1.3, concerning investigation of other elements that may limit their ability to safely accomplish an immediate return landing, was moved to 4.x.1 of AC 25-7D to address the new proposed requirements in § 25.127. The new guidance for AC 25-7D § 25.1.1.3 was added to emphasize that adding design

Regulation	Guidance
features (e.g. a jettisoning system) may be necessary to comply with this requirement, but that it is also likely that AFM limitations will be used as a practical solution to ensure compliance across the entire flight envelope. The guidance in 25.1.1.4 was clarified to specify the go-around configuration and procedures to be used. This guidance was originally intended for overweight return landing situations but lacked enough definition for applicants to understand the intent. The revised paragraph still specifies that it should be determined in which conditions a positive rate of climb can be achieved following an engine-inoperative approach to land, but it also states that if these criteria cannot be met, appropriate mitigations should be put in place. Guidance was added for AC 25-7D § 24.1.1.5 to ensure that it is clear to applicants that when a jettisoning system is needed for reasons other than to satisfy § 25.1001(a), the jettisoning system design requirements of § 25.1001(c),(d),(e),(f),(g),(h),(i) are still applicable.	

(Proposed changes are identified in *red italic characters*):

Regulation	Guidance
Sec 25.127 *Immediate return or diversion landing capability* *(a) The airplane must be designed to conduct an immediate return landing to the departure runway for events occurring soon after takeoff which do not degrade the landing performance capability of the airplane. In addition, the airplane must be designed to be capable of an immediate return landing to the departure runway with one engine inoperative. This landing capability must be shown for weights above maximum landing weight up to maximum takeoff weight minus the computed weight of fuel necessary for a 15 minute flight, comprised of a takeoff and a return to the departure airport, assuming a smooth, dry or wet, hard-surfaced runway. Available landing distance, maximum brake energy, maximum tire speed, margin to flap limit speeds, and flap load relief operation speeds in turbulent air must not be exceeded for this immediate landing. Airplanes with a fuel jettisoning system may show this landing capability assuming up to a 30 minute flight including 15 minutes of jettisoning.*	*AC-25-7D* *4.x Immediate return or diversion landing capability—§ 25.127* *4.x.1 Airplanes must be investigated for factors that may limit their ability to safely accomplish immediate return or diversion landings. Advances in wing design and propulsion technology have resulted in transport category airplane designs that can take off at weights considerably above their maximum landing weights. Many of these airplanes are capable of meeting the climb gradient requirements of §§ 25.119(a) and 25.121(d)(2)(i), following a 15-minute flight, without a fuel jettisoning system, but may not be capable of landing without exceeding other limits including maximum brake energy, available landing distance, and maximum tire speed. This is particularly true when operating procedures with failures call for reduced flap settings and approach speed increases of as much as 30 knots, for a given weight, over the speeds associated with the normal landing flap setting. Margins to flap placard limit speeds and flap load-relief operation speeds should be established and maintained for non-normal configurations which may be encountered in these situations. Immediate return or diversion landings must not require exceptional piloting strength, skill, or alertness.* *4.x.2 The events causing immediate return or diversion landings soon after takeoff may include system failures or non-system related events including medical or security issues. A distinction has been made between the events requiring an immediate landing which are addressed in 25.127(a), and the events addressed in 25.127(b) which involve failures that can be mitigated for continued safe flight, but have elevated risk and for which extended*

Regulation	Guidance
	flight is not recommended. Failure cases that are shown to be extremely improbable need not be considered for this Section. *4.x.3 The hazards identified in 25.127 may be directly addressed with design features to improve the landing performance such as a fuel jettisoning system, added system redundancies, brake sizing, and thrust reversers, however, limitations to AFM takeoff weight may also be employed to ensure the required capability for both immediate return and diversion landings.* *4.x.4 The two types of events to be considered as the cause of an immediate return landing are (1) those in which the airplane landing performance is typically not degraded, and (2) a single engine failure with any associated landing performance degradation. It should be assumed that the crew will try to land on the departure runway with no more than 15 minutes of flight or, if jettisoning is available, a 30 minute flight with 15 minutes of jettisoning. Examples of the first type of event are smoke, fire, or fumes that become uncontrollable, cargo door open warnings, shattered cockpit windows or a level of vibration that prompts immediate action by the crew. The airplane design should be evaluated with a performance analysis to ensure the airplane, without further failures or damage affecting the landing performance, can land immediately without exceeding the performance limits listed in 4.x.1 on smooth, dry and wet, hard-surfaced runways, across the full operational temperature and altitude range, above maximum landing weight. To simplify the performance analysis, it may be assumed that there is no runway slope or wind on takeoff and landing. It should be assumed that the surface condition of the runway does not change between takeoff and landing, being either dry or wet. To determine if the airplane can land immediately, the performance analysis should compare the AFM takeoff field length to the landing distance on the same runway. This landing distance should reflect the capability of the airplane using all available means of deceleration consistent with operating procedures. The Time-of-Arrival Landing Performance Assessment methodology outlined in AC 25-32 assuming an inoperative engine without an operational safety factor (e.g., 15%) is an acceptable method to determine this landing distance in this design analysis. To address the potential immediate return landing due to an engine failure soon after takeoff, the landing distance should be determined in accordance with the applicable one-engine-inoperative landing procedures, including recommended landing configuration and airspeed, if this results in a longer distance than with all engines operating. Operational and regulatory factors on landing distance need not be considered in the landing distance calculation. Because the intent of this immediate landing requirement is to address high-energy overweight landing situations, takeoff runways below 6,000 ft in length need not be considered in the analysis. For operations at elevations above 10,000 ft, takeoff runways below 8,000 feet in length need not be considered.*

Regulation	Guidance
(b) For events or system failures that occur soon after takeoff, that cause a degraded state of flight control and adversely affect handling, but do not require immediate landing per procedure, the airplane must be designed to be able to land and stop safely on a suitable alternate runway with a smooth, dry, hard surface within 60 minutes, or within 90 minutes for failures that have an extremely remote probability. Events or failures addressed in paragraph (a), failures not affecting control or handling, and those that are shown to be extremely improbable soon after takeoff do not need to be considered in this design requirement.	*4.x.5 The airplane design analysis must also consider system failures that occur soon after takeoff that can cause a degraded state of flight control which affects handling and puts the airplane in a state for which extended flight is not recommended or expected. This analysis does not need to include consideration of additional failures after the airplane is configured for landing. Example situations to be considered include failure of multiple hydraulic systems, jammed or restricted flight controls, and flaps failed in the extended position. Although it may be assumed that these failures do not require an immediate landing, the airplane design should be evaluated with a landing performance analysis to ensure that the airplane can land safely following takeoff at MTOW within 60 minutes of flight time on a suitable runway for failures early in the flight that are more probable than extremely remote (1×10^{-7} per flight hour). Up to 90 minutes flight time is allowed if the failure condition is extremely remote (less than 1×10^{-7} but greater than 1×10^{-9} per flight hour). It may be assumed in the analysis that a suitable runway has 8,000 ft field length, is at sea level, standard temperature, with a smooth, dry, hard-surfaced runway. Landing weights at or below maximum landing weight do not need to be evaluated, and the landing distance should be determined using appropriate methods consistent with the associated non-normal procedures using all available means of deceleration in the failed configuration. To simplify the performance analysis, it may be assumed that there is no runway slope or wind on landing. An alternative suitable runway field length and diversion time may be proposed by the applicant using different reference assumptions if they are valid for the expected operations of a particular airplane design.*

Rationale

One of the burdens of the existing standards is the lack of guidance to identify which failures should be considered for immediate landing situations. Without sufficient guidance, OEM's have used methods consistent with their respective design philosophies, but not consistent across the industry. This inconsistency put regulators in the position of evaluating a variance of compliance methodologies that resulted in varied effects on airplane design and operating procedures that were not anticipated. The working group studied the failures and other events in the fleet that prompted immediate landings. Fleet data show that engine failures, smoke, fire, odors, and vibrations often prompt urgent action, so the FTHWG agreed that these scenarios should be addressed in the design of the airplane as immediate return landings. There were discussions and studies of fleet data of failures that affected landing performance (e.g. jammed flaps or hydraulic failures) and it was concluded that these failures on their own do not direct the flight crew to consider an immediate landing in the operating procedures. The working group concluded that the airplane should not be designed to consider the combination of an event prompting immediate landing and an independent failure that degrades the landing performance. The result was that Paragraph (a) of this proposed requirement recommends that airplanes are designed to be capable of landing overweight without delay on the departure runway because of an engine failure or other events that do not affect landing performance.

A difficulty in defining the requirements of Paragraph (a) was how to define the takeoff vs. landing distance performance analysis for immediate return landings. The intent was to compare the AFM takeoff field length to the unfactored landing distance capability of the airplane for an immediate return landing, however, there can be differences between the maximum capability of the airplane and the distance expected using the manufacturer furnished procedures for normal and overweight landings. While the AFM takeoff field length was generally understood in the group, there were various opinions on how to define the landing distance for this design requirement. One proposal was to use what is published in the various manufacturer's AFMs for landing distance without any operational factors. Another was to reference the FTHWG report on Wet Runway Landing without the regulatory or operational factors. Also, an increasing number of OEM's provide advisory data that can be used for time of arrival landing distance assessments. Because of this inconsistency in the industry, and the

Regulation	Guidance

fact that this design analysis should be completed far in advance of the final AFM or operating procedures delivered with the design, it was decided to not overly-constrain the landing distance portion of the analysis, but it was noted that an acceptable method would be to use the Time of Arrival Landing Distance Assessment methodology in AC 25-32 without the 15% operational factor. The guidance for Paragraph (a) notes that the landing distance assumed for the design analysis should be consistent with the operating procedures, including those associated with an engine-out landing. An applicant may choose to be conservative in the analysis to cover uncertainty in the design process, which may not be strictly consistent with anticipated operations, but would be acceptable and promote a safe design. Since the landing distance in this analysis was intended to reflect the capability of the airplane in a non-normal or emergency situation using all available means of deceleration, the use of thrust reversers was assumed.

The most critical design case defined by the FTHWG for immediate return landing distance was a wet runway takeoff with a subsequent engine failure causing an overweight return landing to the same wet runway. Manufacturer studies of the critical cases found that for the most part, current designs are able to meet this requirement with some exposures below maximum landing weight and on relatively short runways with wet surfaces. It was decided that this immediate return landing design assessment was not necessary for operations from runways less than 6,000 ft in length, which was considered a reasonable lower limit for medium and large jet transports by the FTHWG. While it was noted that some regional jets can operate up to MTOW within this field length, 6,000 ft was considered a reasonable value and in-line with the original intent of the regulation. The capability of turboprop airplanes to operate into shorter runways was discussed but their exposure to immediate return landing or diversion hazards was not emphasized by any FTHWG members throughout the discussions, nor were there fleet incidents identified. Because of this, there was no effort to create a shorter minimum runway length to drive the design of smaller jet and turboprop airplanes.

As stated in the underlying safety issues of this report, one of the primary concerns was overweight landings and the hazards associated with exceeding performance limits. To simplify and focus the performance analysis for the immediate return landing design requirements of Paragraph (a), the weight range was focused on cases that would exceed maximum landing weight (MLW). Depending on the design, immediate return landings at or below MLW (normal weight range) could have some exposure to landing distance, but brake energy and tire speed would not be a concern. There was a concern in the FTHWG that including landing weights at or below MLW in the requirement could lead to takeoff weight limitations in situations that were not been shown to be a problem in the fleet, or were part of the underlying safety concern. MLW was chosen as a relevant analysis boundary to address the underlying safety concerns. It was not shown that including weights below MLW would be effective at improving airplane design for immediate return landings.

Some airplanes are qualified to take performance credit for wet grooved/PFC or may in the future obtain credit for some other new wet runway friction surfaces. Fleet studies have shown that the landing distances for most airplanes needing this credit is less than 6,000 ft using all available means of stopping. The FTHWG agreed that this proposed design standard would not benefit by adding complexity to the analysis by including consideration of improved performance runway surfaces.

Similar to the requirements of Paragraph (a), the guidance in 4.x.5 of AC 25-7D defines the weight range for the Paragraph (b) design analysis to be limited to cases that would exceed maximum landing weight (MLW). This was considered to be a relevant boundary to address the underlying safety concerns. It should also be noted that there will be onboard landing performance information for flight crews in failure situations causing diversions both above and below MLW and they have the authority to extend the flight to find the most suitable runway.

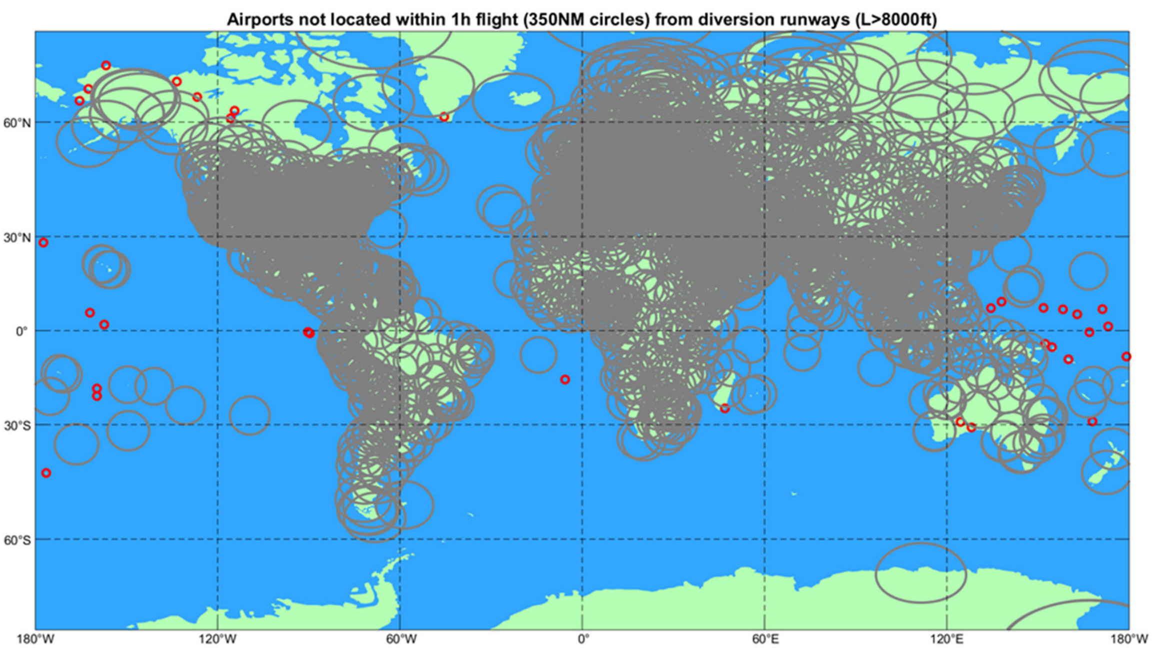
Paragraph (b) of the proposed new requirement is focused on certain types of failure cases occurring soon after takeoff to ensure that the airplane is designed to be able to land with a reasonably short time delay on a suitable runway. Fleet studies and manufacturer failure analyses indicated that the vast majority of failures would not be of concern or affect landing performance. The failures of concern were defined as those causing a degraded state of flight control that adversely affect handling. Flight with these failures prolongs exposure to degraded systems and aggravates the level of risk. Current design requirements address the risk of system failure, but do not limit the time exposure for failures immediately after takeoff. Because of the variations in system designs, failure assessment methods, and operating procedures used to mitigate these failure cases across the industry, the FTHWG did not define a comprehensive list of failures to be considered for this requirement. The proposal defines the requirement to address severe failures, such as dual hydraulic failures, that degrade systems and adversely affect handling.

Regulation	Guidance

The FTHWG studied a broad range of commercial and private jet operations to determine what diversion time and runway length was reasonable for this design analysis. The gray circles on Figure 3 show which runways in the world have at least an 8,000 ft long alternate runway within 350 nm (approximately a one hour diversion). These circles confirm that nearly every commercial airport in the world longer than 4,000 ft and at least 90 ft wide have a suitable alternate approximately 1 hour away. The red circles show there are 33 commercial airports in the world without such an alternate available out of approximately 3,300 airports, and most of these 33 airports have relatively low frequency, making the overall fleet exposure very small. If a diversion of 90 minutes, instead of 60 minutes were assumed, the gray circles would encompass many of the remaining red airports. Based on this rationale, and manufacturer studies of landing performance with system failures, it was agreed that airplanes with failures soon after takeoff that adversely affect handling that are more probable than extremely remote (1×10^{-7} per flight hour) should be designed assuming an 8,000 ft long landing alternate is available in 60 minutes of flight time. Because more severe failures such as dual hydraulic failures are less probable, it was agreed that in the case of extremely remote failures early in flight (less than 1×10^{-7} but greater than 1×10^{-9} per flight hour), the airplane may be designed assuming an 8,000 ft (or longer) landing alternate is available within 90 minutes instead of 60 minutes.

The FTHWG discussed the possibility that applicants might propose longer diversion landing runway lengths than 8,000 ft as an alternative means of compliance when their basic airplane takeoff performance at MTOW requires a longer than 8,000 ft departure runway. The applicant would have the burden of showing that the airplane would be expected to operate from runways longer than 8,000 ft and provide an analysis similar to that used for Figure 3 which would show longer diversion runways are available the vast majority of the time. In the case of an extremely remote failure, where a 90 minute diversion can be assumed, it may also be assumed that a longer diversion runway is available if it is shown to be consistent with expected operations.

Figure 3 – Airports with diversion runways within 350 nm



The relatively slow speed and shorter diversion range in one hour of turboprop airplanes compared to jets was considered to determine if they should have a shorter diversion runway length assumption (instead of 8,000 ft). An 8,000 ft diversion runway length assumption would be unlikely to drive design changes for turboprops, however, the exposure of turboprops to the diversion hazards was not identified by FTHWG members throughout the discussions, nor were there fleet incidents identified. As a result, there was no effort to create a shorter diversion runway length to drive the design of turboprop airplanes.

Although many airplanes are qualified through ETOPS and continued safe flight regulations to fly for hours with similar failure cases when there is no suitable runway available, paragraph (b) of this requirement ensures the airplane is designed to be capable of landing relatively quickly (within 60 to 90 minutes of the departure airport). This new requirement may drive design features in new airplane designs, although the FTHWG did not identify problems with existing designs. In the specified

Regulation	**Guidance**
failure situations encountered soon after takeoff, the flight crew will be assured of the capability to land and avoid diverting or circling for multiple hours to seek a suitable runway. In actual operations flight crews will always have the authority to land immediately or extend the flight as they see fit. It is not the intent of these proposed diversion landing design requirements to impose operational or AFM flight time limits.	

(Proposed changes are identified in *red italic characters*):

Regulation	**Guidance**
Sec. 25.1001 Fuel jettisoning system	AC 25-22 – Certification of Transport Airplane Mechanical Systems 43. SECTION 25.1001 - FUEL JETTISONING SYSTEM. a. Rule Text. *(a) A fuel jettisoning system must be installed on each airplane unless it is shown that the airplane meets the (non-icing) minimum climb gradient requirements of §§ 25.119(a) and 25.121(d)(2)(i) at maximum takeoff weight, less the actual or computed weight of fuel necessary for a 15-minute flight comprised of a takeoff, return to land, approach, and initiation of go-around~~, and landing~~ at the airport of departure with the airplane configuration, speed, power, and thrust the same as that used in meeting the applicable takeoff, approach, and landing climb performance requirements of this P~~p~~art. It is also acceptable to consider the use of emergency (non-normal) approach and landing flap configurations and speeds, if those procedures are applicable.* *(b) If a fuel jettisoning system is required it must be capable of jettisoning enough fuel within 15 minutes, starting with the weight given in paragraph (a) of this section, to enable the airplane to meet the (non-icing) minimum climb gradient requirements of §§ 25.119(a) and 25.121(d)(2)(i), assuming that the fuel is jettisoned under the conditions, except weight, found least favorable during the flight tests prescribed in paragraph (c) of this section.* *(c) Fuel jettisoning must be demonstrated beginning at maximum takeoff weight with flaps and landing gear up and in-* *(1) A power-off glide at ~~1.4 Vs1~~1.3* V_{SR1}*;* *(2) A climb at the one-engine inoperative best rate-of-climb speed, with the critical engine inoperative and the remaining engines at maximum continuous power; and* *(3) Level flight at ~~1.4 Vs1~~1.3*V_{SR1}*; if the results of the tests in the conditions specified in paragraphs (c) (1) and (2) of this section show that this condition could be critical.* *(d) During the flight tests prescribed in paragraph (c) of this section, it must be shown that-*

Regulation	Guidance
	(1) The fuel jettisoning system and its operation are free from fire hazard; *(2) The fuel discharges clear of any part of the airplane;* *(3) Fuel or fumes do not enter any parts of the airplane; and* *(4) The jettisoning operation does not adversely affect the controllability of the airplane.* *(e) For reciprocating engine powered airplanes, means must be provided to prevent jettisoning the fuel in the tanks used for takeoff and landing below the level allowing 45 minutes flight at 75 percent maximum continuous power. However, if there is an auxiliary control independent of the main jettisoning control, the system may be designed to jettison the remaining fuel by means of the auxiliary jettisoning control.* *(f) For turbine engine powered airplanes, means must be provided to prevent jettisoning the fuel in the tanks used for takeoff and landing below the level allowing climb from sea level to 10,000 feet and thereafter allowing 45 minutes cruise at a speed for maximum range. However, if there is an auxiliary control independent of the main jettisoning control, the system may be designed to jettison the remaining fuel by means of the auxiliary jettisoning control.* *(g) The fuel jettisoning valve must be designed to allow flight personnel to close the valve during any part of the jettisoning operation.* *(h) Unless it is shown that using any means (including flaps, slots, and slats) for changing the airflow across or around the wings does not adversely affect fuel jettisoning, there must be a placard, adjacent to the jettisoning control, to warn flight crewmembers against jettisoning fuel while the means that change the airflow are being used.* *(i) The fuel jettisoning system must be designed so that any reasonably probable single malfunction in the system will not result in a hazardous condition due to unsymmetrical jettisoning of, or inability to jettison, fuel.* *[Doc. No. 5066, 29 FR 18291, Dec. 24, 1964, as amended by Amdt. 25-18, 33 FR 12226, Aug. 30, 1968; Amdt. 25-57, 49 FR 6848, Feb. 23, 1984; Amdt. 25-108, 67 FR 70827, Nov. 26, 2002]* NOTE: This regulation will be the subject of a Federal Aviation Regulations/Joint Aviation Requirements (FAR/JAR) harmonization effort under the Aviation Rulemaking Advisory Committee (ARAC). The ARAC working group may recommend revisions to the regulation and any associated advisory material. ~~*NOTE: For policy and guidance on compliance with this requirement, see Advisory Circular (AC) 25-XX, Propulsion Systems Handbook. This regulation may require special consideration for certain equipment where the airplane is not capable of a return landing without exceeding equipment ratings/capabilities such as brakes and tires. Brake maximum kinetic energy rating(s) and tire maximum speed ratings may be exceeded for an immediate return/turnback, or a flapless landing, especially for large two engine airplanes.*~~

Regulation	Guidance
Rationale The rule text in AC 25-22 should be updated to reflect Amdt 25-108 and as Section 25.1001 is revised as recommended. The last sentence in the second note of Paragraph 43 states that the "kinetic energy rating(s) and tire maximum speed ratings may be exceeded for an immediate return/turnback, or a flapless landing, especially for large two engine airplanes." The FTHWG found it confusing that it seemed permissive of these exceedances, which is not believed to be the intent. It is proposed that this entire note be deleted as the concern is better addressed in the proposed changes to AC 25-7D.	