June 21, 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 18 Final Recommendation Report

Dear Mr. Roberts,

On June 20, 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 the following areas: Commercial Pilot – Powered-Lift; Commercial Pilot – Helicopter; and Instrument Rating – Helicopter.

The ARAC also voted to accept the Final Recommendation Report submitted by the Flight Test Harmonization Working Group (FTHWG) on Topic 18 – Go-around Handling Qualities and Performance.

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 Topic 18
Go-Around Handling Qualities & Performance

Recommendation Report
December, 2018

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Executive Summary

The Flight Test Harmonization Working Group has been tasked to recommend appropriate revisions to go-around All Engine Operative (AEO) and One Engine Inoperative (OEI) regulatory and advisory material (refer to Work plan Attachment 18A).
The task consisted of reviewing the related FAA/EASA/TCCA/ANAC Part 25 regulatory and advisory material, also reviewing CRIs/IPs published for recent certifications and OEMs best practices to offer harmonized criteria for Go-Around Handling Qualities and Performance.

Although there are existing regulations and guidance intended to ensure each airplane is safely controllable and maneuverable in each flight phase, the AEO go-around is not specifically identified as a flight phase or maneuver to be evaluated during airplane airworthiness certification. In addition, current regulations require the applicant to establish balked landing and missed-approach Airplane Flight Manual (AFM) procedures for AEO and OEI conditions ensuring that they are safe and can be executed by crews of average skill. However, recently identified safety concerns regarding pilot disorientation during high power all-engine go-arounds and excessive horizontal distance to achieve the required single-engine climb gradient for an OEI missed approach are not specifically addressed by the current advisory material.

As a conclusion of this in-depth review, the FTHWG recommends to amend several Part 25 Subpart B paragraphs addressing Performance and Handling Characteristics, together with associated FAA AC 25-7C guidance material paragraphs.
This report provides the FTHWG new proposed standards and guidance for both OEI and AEO go-around cases.

- For OEI go-around, the proposed new guidance is based upon existing AC 25-7C guidance and EASA advisory material in AMC 25-101(g) introduced at Amendment 13, including safe demonstration of an OEI go-around from the minimum decision height consistent with the weather minima criteria being approved (CAT 1 or CAT 2 operations). In addition, the safety concern identified during recent certification projects related to excessive OEI go-around horizontal distance is addressed by introducing a new trajectory criterion for safe OEI go-around.

- For AEO go-around, new regulations and guidance are proposed based upon EASA CS 25 published at Amendment 21 on 27 March 2018 (with the embodiment of NPA 2017-06, 'Loss of control or loss of flight path during go-around or other flight phases') addressing mitigation of the risk of excessive crew workload and risk of somatogravic illusion that may appear during go-around conducted typically in combined conditions i.e.: low visibility /High Thrust. To address this issue, CS 25 Amendment 21 establishes additional specific AEO go-around demonstrations and evaluations to be conducted through specific updates of CS 25 §25.143 (Controllability and Maneuverability-General), §25.145 (Longitudinal control) and CS 25 Appendix Q (Steep Approach and Landing) and their associated guidance material.

To conclude,

- The following Part 25 Subpart B paragraphs are recommended to be updated:
  §25.143 (Controllability and Maneuverability-General),
  §25.145 (Longitudinal Control)

- The following AC 25.7C paragraphs are recommended to be updated:
  § 7 (25.121(d)),
  Add a new §9 for new 25.101(g) guidance,
  §16 (Landing climb All engines operating- 25.119),
  § 20 (General-25.143),
  §21 (Longitudinal Control- 25.145),
  §231 (Criteria for Approval of Steep Approach To Landing)

Background

1) OEI go-around:

Existing EASA CS §25.101(g), (h) and FAA 14 CFR 25.101(g), (h) require that procedures for the execution of missed approaches associated with conditions prescribed in CS/CFR §25.121(d) be established and demonstrated to be safe and able to be executed by crews of average skill. Existing AC 25-7C guidance for 25.121(d) refers to 25.101(g) & (h) with a flight test at a Weight-Altitude-Temperature (WAT) limit condition to demonstrate the acceptability of the missed approach procedures. No particular guidance was given in CS 25 until CS 25 Amendment 13 introduced new AMC 25.101(g), which differs from the AC25-7C guidance and introduces a link to the operational weather minima and associated "decision height", which led to a dis-harmonization between EASA and FAA guidance.

Also, the JAA Flight Study Group had previously identified two safety topics related to go-around procedure execution, in particular in the context of low-weather minima conditions (ref FWP 479 dated 1994, FWP 623-1 dated 1999, FWP 731-1 dated 2002). The first topic is relative to the potential impossibility for an aircraft to go-around from a low decision height without striking the ground. The second topic is relative to the potential long go-around distance near the ground in case the increase between approach speed and go-around speed defined consistently with §25.121(d) is large.

There have been different EASA/JAA CRIs and TCCA Certification Memoranda raised on different products requesting different compliance demonstration against §25.101(g).

The FTHWG has been tasked to develop and recommend harmonized guidance material.

2) AEO go-around:

A number of accidents or serious incidents with commercial transport large airplanes have occurred due to high level of airplane performance when conducting an AEO go-around. In some cases, limited available pitch authority was considered a contributing factor.
In light of the French 'Bureau d'Enquête Accident' (BEA) report published in August 2013 on Airplane State Awareness during Go-Around (ASAGA) and occurrences analysis during or after a go-around with loss of control of flight path, or loss of control of the aircraft, two contributing factors were identified:

- High thrust causing somatogravic illusion (*): the CS 25 Amendment 21 specifically requires the assessment of AEO go-around maneuver and associated procedures. In addition, the applicant may propose to implement a Reduced Go-Around thrust (RGA) function.

- Pitch trim position at, or close to the full nose up position (crew being not aware of it): the CS 25.145(f) (equivalent of the proposed 25.145(e) of this report) requirement to demonstrate adequate longitudinal and speed control during AEO go-around maneuvers, including accounting for expected adverse pitch trim positions in both manual and automatic flight modes.

Note (*): somatogravic illusion is a spatial dis-orientation caused by a mismatch between different signals from our senses and the brain. It is generated by a strong longitudinal acceleration or deceleration. The brain interprets acceleration as a pitch up and this may lead to an inappropriate pitch down command.

It is considered that the risk of somatogravic illusion is high when combining high values of pitch-up angle, pitch rate, and longitudinal acceleration, together with a loss of outside visual reference

Figure 01 below illustrates the phenomenon:

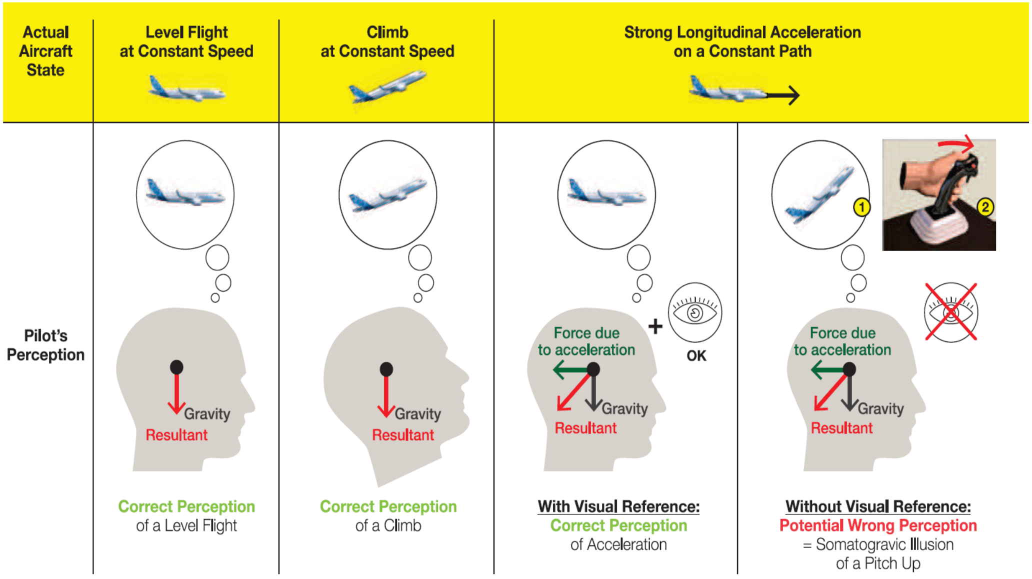


FIGURE 01: Somatogravic illusion explanation

The FTHWG has been tasked to review and capitalize on EASA RMT 0647 activities, NPA 2017-06 (published 11 May 2017), NPA Comment and Response Document and CS 25 Amendment 21 (published on 23 March 2018). The goal is to develop harmonized standards to mitigate the potential risk of excessive crew workload and somatogravic illusion that may appear during AEO go-around conducted typically in combined conditions i.e.: low visibility /High Thrust.

A. What is the underlying safety issue addressed by the FAA CFR / EASA CS?

1) OEI go-around:

Although OEI go-around in WAT (Weight - Altitude - Temperature) limit conditions has not been formally identified as the root cause of in-service accidents, there are 2 topics of concern:

- The first topic is relative to the ability of an aircraft to go-around from a low decision height without striking the ground.

- The second topic is relative to the potential for an excessive go-around distance near the ground while accelerating between the approach speed and the go-around speed as defined in §25.121(d).

It is to be noted that these two potential safety issues should be considered with regards to the low probability of the scenario. To be critical, this scenario requires a go-around decision at a low height in concurrence with an unanticipated engine failure and being in WAT limit conditions.

2) AEO go-around:

A number of accidents or serious incidents with commercial air transport large airplanes have occurred either during or at the end of a go-around phase, and with the pilots attempting to climb. A loss of the normal go-around flight path or loss of control of the airplane has been observed in relation to inadequate flight crew awareness of the airplane's state, or inadequate management by the flight crew of the relationship between pitch attitude and thrust. Unusual pitch-up trim position has also been a factor in some occurrences.
Contributing factors for these accidents included difficulty for the flight crew to manage the go-around manoeuvre mainly due to the high level of aeroplane performance leading to somatogravic illusion and due to the limited available pitch authority.

Extract from NPA 2017-06 related to go-around occurrences:

25 occurrences (12 accidents and 13 incidents – 849 fatalities)
12 Airbus (6 A300/A310, 4 A319/A320, 2 A330);
10 Boeing (2 B737-300, 3 B737-500, 1 B737-800, 2 B757-200, 2 B777);
1 Mc Donnell Douglas DC-8-63;
1 Swearingen SA226 TC Metro II (small aeroplane);
1 Bombardier DHC-8-103

Contributing factors:
- ***High thrust** application is involved in 16 occurrences (8 accidents, 8 incidents or serious incidents),*
- *Spatial disorientation in the form of **somatogravic illusion** is identified as probable factor in 9 occurrences (7 accidents, 2 serious incidents),*
- *A **pitch trim position** at, or close to, the full nose-up position is involved in 7 occurrences (3 accidents, 4 incidents or serious incidents).*

B. What is the task?

The task is to harmonize regulations and guidance material for Go-Around between Authorities for AEO and OEI cases.

Recent EASA material, AMC 25.101(g) introduced in CS 25 at Amendment 13 and updates of §§ 25.143, 25.145 (with their respective AMCs) and Appendix Q introduced in CS 25 at Amendment 21, establish the need for harmonized criteria for Handling Qualities, Performance and Procedures:

- For OEI go-around in WAT limit conditions, establish (if needed), criteria for height loss, trajectory, and timing of climb gradient capability relevant or necessary for decision height consistent with the weather minima to be approved for operations.

- For AEO go-around, evaluate the EASA NPA 2017-06 published on 11 May 2017 produced by the EASA RMT 0647 activities and embodied in CS 25 published on 27 March 2018 at Amendment 21. The specific objective is to mitigate the safety risk for Part 25 Transport Category airplanes of loss of the normal go-around flight path, or loss of control of the aircraft during go-around, ensuring that:

  — The design of Part 25 Transport Category airplanes is such that the AEO go-around procedure with all engines operating (AEO) can be safely conducted by the flight crew without requiring exceptional piloting skill or alertness. The risk of excessive crew workload and the risk of somatogravic illusion must be carefully evaluated, and design mitigation measures must be put in place if those risks are too high;

  — The design of Part 25 Transport Category airplanes provides adequate longitudinal controllability and authority during go-around.

Note that the EASA CS 25 Amendment 21 has a wider scope compared to FTHWG-Topic 18 because it covers loss of control of the aircraft during go-around and other flight phases executed at low-speed. The FTHWG Topic 18 task considered the go-around flight phase only.

See also Attachment 18A - Topic 18 Work Plan

C. Why is this task needed?

1) OEI go-around:

- Existing FAA guidance material for §25.101(g) does not explicitly require height loss data when demonstrating the missed approach procedure, nor does it consider whether excessive time or distance is required to achieve the conditions of §25.121(d).

- EASA has provided guidance material via Certification Review Item (CRI) since the early 2000's, and introduced, at CS 25 Amendment 13 a new AMC 25.101(g).

- TCCA has provided guidance in TCCA AC 525-009 'Controllability during approach and landing V_{MCL} considerations' which introduced an additional minimum constraint on the approach climb speed of 1.1 V_{MCL} used to show compliance with §25.121(d).

Moreover, there are differences between the EASA CRIs and TCCA Certification Memorandum (with different compliance expectations) applied on different products and OEMs on past programs.

The task is needed to introduce harmonized acceptable Means of Compliance in AC 25-7C and EASA CS 25 Book 2.

2) AEO go-around:

A number of accidents or serious incidents with commercial air transport large airplanes have occurred either during or at the end of a go-around phase, and with the pilots attempting to climb. Contributing factors for these accidents included difficulty for the flight crew to manage the go-around maneuver mainly due to the high level of airplane performance leading to somatogravic illusion and due to the limited available pitch authority.

Although there are existing regulations and guidance intended to ensure each airplane is safely controllable and maneuverable in each flight phase, the AEO go-around is not specifically identified as a flight phase or maneuver to be evaluated during airplane airworthiness certification.

EASA CS 25-Amandmant 21 published on 27 March 2018 has introduced new regulations and guidance for AEO go-around. This task is needed to recommend comparable changes to FAA 14 CFR 25 and provide FTHWG comments to EASA relative to CS 25-Amendment 21.

D. Who has worked the task?

The FTHWG, during Phase 3 activities, has worked the task. Three face–to-face meetings and 21 telecons were dedicated to this topic.

Participants in this FTHWG task included:

Airframe Manufacturers:
Airbus, Boeing, Bombardier, Dassault, Embraer, Gulfstream and Textron

Airworthiness Authorities:
FAA, EASA, TCCA, ANAC (CAAI and JCAB as observers)

Operators:
Norwegian (as an observer)

Labor Union:
ALPA

E. Any relation with other topics?

1) OEI go-around:

FTHWG Topic 20 Return to Land (i.e. go-around climb gradient)

2) AEO go-around:

During the robustness maneuver discussions for FTHWG Topic 1 and 2, rapid rotation and thrust application representative for critical go-around, and pitch attitude limitation were discussed.

FTHWG Topic 12- Steep Approach and Landing

Historical Information

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

1) OEI go-around:

CS 25 and FAR 25 require that procedures for the execution of missed approaches associated with conditions prescribed in CS/FAR 25.121(d) be established and demonstrated safe.

CS/FAR 25.121(d)
Approach. In a configuration corresponding to the normal all-engines operating procedure in which V_{SR} *for this configuration does not exceed 110 % of the* V_{SR} *for the related all-engines-operating landing configuration:*
(1) The steady gradient of climb may not be less than 2.1 % for two-engined aeroplanes, 2.4 % for three-engined aeroplanes and 2.7 % for four-engined aeroplanes, with –
(i) The critical engine inoperative, the remaining engines at the go-around power or thrust setting;
(ii) The maximum landing weight;
(iii) A climb speed established in connection with normal landing procedures, but not more than 1.4 V_{SR}*; and*
(iv) Landing gear retracted.

The topic is basically related to the demonstration of a safe go-around procedure, as required by FAR/CS 25.101(g & h) which are harmonized, but advisory material for CS 25 and CFR 25 are not harmonized.

CS/FAR 25.101(g):
Procedures for the execution of balked landings and missed approaches associated with the conditions prescribed in CS 25.119 and 25.121(d) must be established.

CS/FAR 25.101(h):
The procedures established under subparagraphs (f) and (g) of this paragraph must:
(1) Be able to be consistently executed in service by crews of average skill
(2) Use methods or devices that are safe and reliable, and
(3) Include allowance for any time delays in the execution of the procedures, that may reasonably be expected in service.

The guidance material contained in AC 25-7C paragraph 17.b.(7) is given below:

Section 25.121(d) permits the use of a climb speed established in connection with normal landing procedures, but not more than 1.4 V_{SR}. Section 25.101(g) requires that the procedures for the execution of missed approaches associated with the conditions prescribed in § 25.121(d) must be established. Consequently, the speeds and flap configuration used to show compliance with the minimum climb gradient requirements of § 25.121(d) need to be consistent with the speeds and flap configurations specified for go-around in the AFM operating procedures. In order to demonstrate the acceptability of recommended procedures, the applicant should conduct go- around demonstrations to include a weight, altitude, temperature (WAT)-limited or simulated WAT-limited thrust condition. In accordance with § 25.101(h), the established procedures must-

(a) Be able to be consistently executed in service by crews of average skill,

(b) Use methods or devices that are safe and reliable, and

(c) Include allowance for any time delays in the execution of the procedures that may reasonably be expected in service.

The guidance material, expressed in EASA AMC 25.101(g) as per Amendment 13 is given below:

AMC 25.101(g): Go-around
In showing compliance with CS 25.101(g), it should be shown at the landing weight, altitude and temperature (WAT) limit, by test or calculation, that a safe go-around can be made from the minimum decision height with:
- the critical engine inoperative and, where applicable, the propeller feathered,
- a configuration and a speed initially set for landing and then in accordance with the go-around procedures, using actual time delays and, except for movements of the primary flying controls, not less than 1 second between successive crew actions,
- the power available,
- the landing gear selection to the 'up' position being made after a steady positive rate of climb is achieved.

It should be noted that for Category 3 operation, the system will ensure the aircraft is over the runway, so any go-around will be safe with the aircraft rolling on the runway during the manoeuvre. Hence, AMC 25.101 (g) is only relevant to or necessary for decision heights down to Category 2 operations.

In addition, TCCA introduced AMA 525/7 in 02/01/1990 (refer to AC 525-009 'Controllability during approach landing V_{MCL}, considerations') in which the Vapp for the approach climb configuration (25.121(d)) would not be less than 1.1 V_{MCL}

(c) Minimum Approach Speed. The minimum approach speed used to show compliance with the requirements of 525.121(d) should meet the following:

V_{APP} not less than 1.13 V_{SR} (Approach Configuration)

V_{APP} not less than 1.1 V_{MCL} (Approach Configuration)

It should be noted that in accordance with 525.121(d), the one engine inoperative missed approach climb gradient must be met at a speed not exceeding 1.4V_{SR} and V_{SR} for this configuration cannot exceed 110% of the V_{SR} in the corresponding landing configuration.

US and EU Airport and Operational guidance were reviewed and checked that they do not conflict with the proposed recommendation in Attachment 18B.

The operational guidance is as follows:

US Airport and Operational Guidance:
Some relevant aspects of the ICAO PAN-OPS/TERPS guidelines for runway construction and safety dealing with obstacle clearance were reviewed. The conclusion was made that this material was not applicable to OEI go-around, but to AEO go-around only.

Also AC 120-91 (§17) Missed Approaches, Rejected Landings, and Balked Landings was reviewed as it applies to airport obstacle clearance analysis. Although height loss and obstacle clearance are considered, there are no specific guidance either on climb gradient to be achieved or horizontal distance requirements.

AC 120-29A is addressing CAT 1 and CAT 2 weather minima approach operations with considerations of height loss and obstacle clearance.

AC 120-28D addresses consistency of procedures so that the pilots will be familiar with appropriate go-around techniques and they will be used consistently and reliably.

EU Airport and Operational guidance:

EASA Air operations Part- CAT:

- AMC 2 CAT. POL.A.225 missed approach is addressing CAT 1.

- CS-AWO 243 Go-around climb gradient: is addressing CAT 2- *"**the Aeroplane Flight Manual must contain WAT limit corresponding to a gross climb gradient of 2.5%**, with critical engine failed and with the speed and configuration used for go-around, or the information necessary to construct go-around gross flight path with an engine failure at the start of the go-around from the decision height".*

  FAA AC's do not specify climb gradient requirements for CAT 2 operations. As a consequence, there is no equivalence between CS-AWO 243 and FAA AC's.

2) AEO go-around:

The existing 14 CFR 25.143 Controllability and Maneuverability-General and 25.145 Longitudinal Control are intended to ensure each airplane is safely controllable and maneuverable in each flight phase. However, the AEO go-around is not specifically identified as a flight phase or maneuver to be evaluated during airplane airworthiness certification.

On March, 27th 2018, EASA published new requirements and guidance material addressing AEO go-around safe operations in CS 25 at Amendment 21. It is based on NPA 2017-06 and its Comment and Response Document (CRD) also published on March, 27th 2018. AEO go-around demonstrations and evaluations are required by CS 25.143 (Controllability and Maneuverability - General), §25.145 (Longitudinal control) and CS 25 Appendix Q (Steep Approach and Landing) and their associated guidance material.

CS 25.143(a):
The aeroplane must be safely controllable and manoeuvrable during:
(1) take-off;
(2) climb;
(3) level flight;
(4) descent;

(5) approach and go-around; and
(6) approach and landing.

CS 25.143(b):
(4) Go-around manoeuvres with all engines operating. The assessment must include, in addition to controllability and manoeuvrability aspects, the flight crew workload and the risk of a somatogravic illusion. (See AMC 25.143(b)(4))

EASA CS 25 Book 2 AMC 25.143(b)(4) as per Amendment 21 provides detailed advisory material and guidance related to assessment of AEO go-around and the potential for somatogravic illusion.

CS 25.145(f):
It must be possible to maintain adequate longitudinal and speed control under the following conditions without exceptional piloting skill, alertness, or strength, without danger of exceeding the aeroplane limit-load factor and while maintaining an adequate stall margin throughout the manoeuvre:
(1) Starting with the aeroplane in each approved approach and landing configuration, trimmed longitudinally and with the thrust or power setting per CS 25.161(c)(2), perform a go around, transition to the next flight phase and level off at the desired altitude:
(i) with all engines operating and the thrust or power controls moved to the go around power or thrust setting;
(ii) with the configuration changes, as per the approved operating procedures or conventional operating practices; and
(iii) with any practicable combination of Flight Guidance/Autothrust-throttle/Autopilot to be approved, including manual.
(2) Reasonably expected variations in service from the established approach, landing and go around procedures for the operation of the aeroplane must not result in unsafe flight characteristics during the go-around.

EASA CS 25 Book 2 AMC 25.145(f) as per Amendment 21 provides detailed advisory material and guidance for demonstration of acceptable longitudinal controllability for AEO Go-around.

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

1) OEI go-around:

There are currently no regulatory differences between CS 25 and FAA CFR 25.

The current FAA AC 25-7C guidance and EASA AMC 25.101(g) are not harmonized with notable difference being the reference in AMC 25.101(g) to demonstration of the go-around at the minimum decision height associated with the weather minima to be approved, down to CAT 2 minimum of 100 ft.
In addition, TCCA AC 525-009 introduced a constraint on the minimum approach climb speed to show compliance with 525.121(d) in the approach climb configuration.

2) AEO go-around:

On March, 27th, 2018 EASA published new requirements and guidance material addressing AEO go-around safe operations in CS 25 at Amendment 21. It is based on NPA 2017-06 and its Comment and Response Document (CRD) was also published on March 27th, 2018.
CS 25 at Amendment 21 introduces additional specific AEO go-around demonstrations and evaluations to be conducted through specific updates of §25.143 (Controllability and Maneuverability- General), §25.145 (Longitudinal control) and CS 25 Appendix Q (Steep Approach and Landing) and their associated guidance material.

There are currently no equivalent regulations nor advisory material that identify demonstration of safe AEO go-around in FAA 14 CFR 25, although FAA §25.143 requires that the airplane be safely controllable and manoeuvrable during take-off, climb, level flight, approach and landing.

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

1) OEI go-around:

- EASA has a generic CRI B-XX raised for programs with certification basis prior to CS-25 to Amendment 13 (similar to AMC 25.101(g) at Amendment 13).
- For some programs, the JAA had a requirement to comply with a specific go-around trajectory 'bucket' for CAT 2 approvals.
- TCCA has a Certification Memo (CM) raised on the C-Series program.
- The FAA has no IPs.

2) AEO go-around:

There are no existing CRIs or IPs related to AEO go-around for demonstration of controllability and mitigation against somatogravic illusion.

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

1) OEI go-around:

EASA: There are generic CRI B-XX raised for programs with certification basis prior to CS 25 Amendment 13 (similar to AMC 25.101(g) at amendment 13) for which safe go-around compliance has been shown by conducting height loss demonstration capabilities down to CAT 2 operations.

Also, for some recent certifications, in addition to the height loss demonstration consideration, EASA requested to limit the go-around speed specified in 25.121(d) to have an acceptable acceleration time.

In addition, JAA/CAA has required some applicants to comply with a type of go-around 'bucket' for CAT 2 operational approval.

TCCA: There is a Certification Memo (CM) raised on C-Series requesting CAT 1 and CAT 2 height loss demonstration (as EASA AMC 25.101(g)) plus additional demonstration of horizontal and vertical distance to reach the climb gradient for CAT 1 and CAT 2 of 2.5%.

All of these differences have resulted in inconsistent certification approaches between the Authorities regarding this topic, resulting in different means of compliance/data to be provided by the OEMs.

2) AEO go-around:

There are no existing CRIs or IPs related to AEO go-around for demonstration of controllability and mitigation against somatogravic illusion.

Consensus

1) OEI go-around:

A FTHWG majority position has been reached on the proposed material recommendation in Attachment 18B. Nevertheless, TCCA expressed a dissenting position and Bombardier expressed a comment (refer to the table below).

- Height Loss: The group converged rapidly to include the additional height loss demonstration ensuring that ground contact would not occur if initiated at the decision height/altitude in WAT limit conditions.

- Minimum go-around trajectory (reference Figure 9-1 of Attachment 18B): This ensures that the aircraft will not remain near the ground for an excessive distance from the initiation of go-around at the decision height.
  Different criteria were envisaged either by constraining the time or acceleration to reach the go-around speed (a maximum of 1.4 V_{SR} specified in 25.121(d)). Several options were scrutinized, but finally, a time-based horizontal distance criterion was selected by the group, since it was found to be a fair criterion between small and large aircraft acceleration capabilities and operations. This distance criterion is linked to airport field elevation expressed in segment B of Figure 9-1 of Attachment 18B.

- Height loss and minimal go-around trajectory are to be done, depending on the case, by flight test, simulation or analysis. The group agreed that for the simulation option, AC 25-7C §3a(1)(f) is relevant.

- The justification for Segment B is provided below:

  *From the runway threshold plus a distance defined by 40 seconds * V_{T_appr}, not more than a distance equal to the table below – remain above ground height. V_{T_appr} is defined in Attachment 18B.*

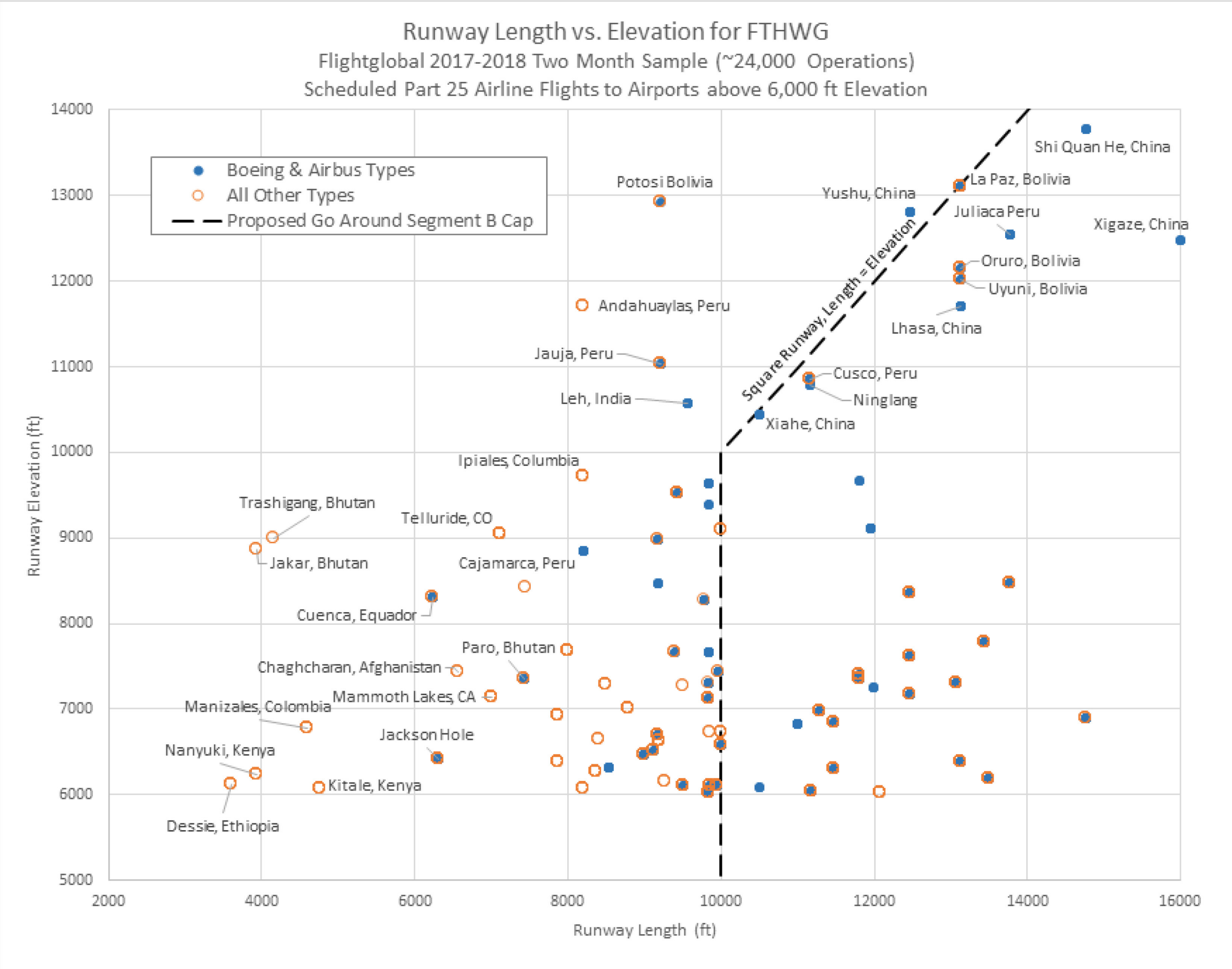
Field Elevation (ft)	Distance (ft)
0-10,000	10,000
> 10,000	= Field Elevation

To better understand the relationship of runway length with field elevation, two months of Part25 worldwide scheduled airline operations were obtained from the Flightglobal database (see Figure 02 below). The FTHWG sought to understand if the assumption of a "square" high elevation airport, i.e. when a runway is the same length as its elevation, is a reasonable reference for a distance after which the minimum climb speed and gradient of 25.121(d) would be achieved. The conclusions drawn from the data were that the Segment B proposal was reasonable:

- For airports above 10,000 ft elevation, most of the runways were better (longer) than square, and the few that were significantly shorter (Potosi, Andahuaylas, Jauja, and Leh) had very low operational frequency (about 1 scheduled flight per week).

- For the operations of larger types (Boeing and Airbus), the airports generally meet the proposed Segment B square criteria and were on the order of 10,000 ft long above 6000 ft elevation. In addition, for most airplanes, the 40s x V_{T_appr} criterion would constrain the horizontal distance below 10,000 ft airfield elevation.

FIGURE 02:



Dissenting Position	FTHWG Answer to the Dissenting Position
TCCA AC 525-009 material guidance includes an additional constraint on the minimum approach speed (i.e. not less than 1.1 V_{MCL}) determined for each configuration used to show compliance with approach climb requirement 525.121(d). TCCA provides the below rationale for keeping this additional minimum speed criteria for the approach climb. To summarize, TCCA has an AC, 525-009, that introduces minimum speed criteria for 525.121(d), Approach Climb, as an acceptable means of compliance. These minimum speeds are: Vapp not less than $1.13V_{SR}$ (Approach Configuration) Vapp not less than 1.1 V_{MCL} (Approach Configuration) In consideration of the TCCA AC 525-009, the impact for the proposed trajectory assessment of FTHWG may be an acceleration to a higher speed for the approach climb than would otherwise be the case if the minimum speed criteria were not imposed. Additionally, the criteria would not likely affect V_{T_appr} for the landing configuration from where the go-around would be initiated, unless an applicant chose to increase V_{REF} to accommodate the acceleration needed for such a case. So the horizontal distance defined by 40s x V_{T_appr} would not be extended but the acceleration to the relatively higher speed may make meeting the "bucket" more difficult. However, it should be noted that the 1.1 V_{MCL} criteria would likely only impact the assessment for aircraft at very light weights; in such cases, density altitude would probably have to be quite high for most aircraft to be WAT limited for this condition. The minimum speed criteria of AC 525-009 were chosen to be analogous with similar minimum speed requirements for take-off V_{2min} (25.107(b)). TCCA considers that the reasons for the minimum speed criteria for 25.107(b) are equally applicable to approach climb. Moreover the following reasons were considered as the basis for the minimum speed criteria in the AC: -To ensure controllability when conducting a go-around in accordance with 25.143; -Approach climb gradients are determined with allowance for 2-3° bank while static V_{MCL} may be demonstrated with up to 5° bank; -Under WAT limited conditions considerable time may be spent at speeds which present challenges to satisfactory execution of a go-around -The workload faced by pilots in conducting a go-around with engine failure is very high and will experience operational conditions not seen when V_{MCL} is demonstrated by flight test pilots in benign flight conditions; and,	The position of the group is to recommend TCCA to remove this additional constraint. The reasons are as follows: - Roll controllability during the V_{MCL} demonstration ensures sufficient margins at the landing reference speed, V_{REF}, as constrained by the harmonized regulation, 525/25.125 (b)(2)(i)(B). Landing V_{REF} is effectively the airspeed at which the dynamic OEI go-around maneuver could be initiated, and as such when controllability during the OEI go-around is most critical. $V_{REF} \geq V_{MCL}$ has been an acceptable standard. - The acceleration from a V_{REF} near or at V_{MCL} to an approach climb speed constrained by $1.1V_{MCL}$ will lead to longer go-around distance at light weight only. This is counter to the objective of this tasking. - This is an additional TCCA requirement that neither CS 25 nor FAR 25 are requiring.

-Past incidents have shown that pilots do not always perform optimally when conducting go-arounds with engine failure. For all of these reasons, TCCA considers that minimum speed criteria be observed in conducting go-arounds with engine failures so that adequate conservatism is maintained.	

Bombardier's comment:

Bombardier airplanes have been using TCCA's AC 525-009 "Controllability During Approach And Landing, V_{MCL} Considerations" as means of compliance on all Bombardier products since the late 1990's.
This AC introduces a minimum speed criteria for 525.121(d) (Minimum 1.1 V_{MCL} on approach climb speed, V_{GA}/V_{APP}).
During the FTHWG Topic 18 activities, it was recognized that Bombardier is the only OEM currently applying this criteria on approach climb speed.
At lighter weights where 1.1 V_{MCL} is limiting V_{GA}/V_{APP}, the acceleration distance from V_{REF} to V_{GA}/V_{APP} will therefore be increased.
However, Bombardier considers that TCCA's AC 525-009 will have no impact on the trajectory requirements determined by the FTHWG Topic 18, since this analysis will be made at heavier weights (WAT Limit) where 1.1 V_{MCL} is typically not limiting V_{GA}/V_{APP}.

Therefore, Bombardier recommends that TCCA's AC 525-009 "Controllability During Approach And Landing, V_{MCL} Considerations" be considered as a future FTHWG topic.
The FTHWG steering committee shall be informed of the special TCCA requirement regarding minimum control speed during landing approach (25.149 V_{MCL}) on approach climb speeds, and a dedicated FTHWG will then discuss if TCCA's AC 525-009 can be harmonized as a certification requirement between agencies in meeting the controllability requirements of 25.143.

2) AEO go-around:

A FTHWG majority position was reached on the proposed material recommendation in Attachment 18C (for rule update) and in Attachment 18D (for guidance update). Nevertheless, some dissenting opinions or comments have been expressed in the table below.

The group consensus was to adopt the CS 25 Amendment 21 updates regarding go-around evaluations in its large majority and to include some updates relative to high Angle of Attack Protected airplanes considerations (coming from FTHWG Topic 1 recommendations during the Phase2).

Nevertheless, the following differences with CS 25 and guidance are to be mentioned:

- In Attachment 18B for the recommended guidance material –OEI go-around in WAT limit conditions, the new §25.101(g) guidance considers RGA if installed on the aircraft.

- In Attachment 18C, the majority vote of this group was not in favor of introducing a 'go-around' flight phase as done in CS 25.143(b)(2). This paragraph deals with sudden failure of the critical engine for airplanes with three or more engines. Indeed, the subject was found to be properly covered by the actual §25.149g (V_{MCL-2}). EASA agreed and stated that it was not EASA's intention to introduce a new V_{MCL-2} reference, and would clarify it in a next issue of CS 25 Amendment publication.

- In Attachment 18D, the guidance material of §25.119 needs to cover consideration of three possible uses of RGA power or thrust:
    1- RGA power or thrust is used in AEO go-around maneuvers as per the normal AFM procedure. The power or thrust available 8 sec after moving the engine controls must be determined by test.

    2- In exceptional circumstances, the pilot may elect to use power or thrust above the RGA settings.
    This can happen in the presence of windshear or unexpected obstacles crossing the flight path. It is not necessary to determine the power or thrust available after 8 sec, since the corresponding go-around performance is not published in the AFM.

    3- A go-around procedure is provided by the applicant and uses power or thrust levels above RGA settings.
    Since power or thrust exceeds RGA levels, this procedure must be approved by the authority. The power or thrust available 8 sec after moving the engine controls must be determined by test.

- In Attachment 18D :
    - the guidance material for 20.h (2)(a) somatogravic illusion (for §25.143 (b) (4)) mentions :

"It is considered that the risk of a somatogravic illusion is high when encountering <u>high longitudinal acceleration or combined high values of pitch attitude (nose-up)</u>, pitch rate and longitudinal acceleration, associated with a loss of outside visual references"

Whereas AMC of 25.143(b)(4) uses the term *'single or combined high values…'* instead of *'high longitudinal acceleration or combined high values….'*. The group agreed that the updated wording added clarity on the fact that longitudinal acceleration effect might be the main contributor for the vertigo effect experienced by crews during high T/W ratio on go-around.

- the guidance material for 20.h (4)(e) and (f) add the underlined sentence below:

(e) Engine failure during go-around with RGA thrust or power

When an engine failure occurs during a go-around performed with active RGA thrust or power, if the required thrust or power from the remaining engine(s) to achieve adequate performance level cannot be applied automatically, a warning alert to the flight crew is required to prompt them to take the necessary thrust or power recovery action. <u>For non-moving auto-throttle lever designs or manual thrust setting procedures, compelling flight deck alerts may be acceptable in lieu of automatic thrust recovery of the operating engine to permit use of maximum go-around thrust for §25.121(d) compliance.</u>

....

(f) Performance published in the AFM for RGA thrust or power

The climb performance required by §25.119 (in a landing climb, i.e. with all engines operating) should be based on the actual RGA thrust or power available (applied by following the recommended AFM procedure). The climb performance required by §25.121 (in an approach climb, i.e. with one engine inoperative) should be based on:

— either the RGA thrust or power available, if no thrust or power recovery is implemented,

— or the go-around thrust or power available after the application of the thrust or power recovery action (either automatically, or manually after an alert is triggered). <u>For non-moving auto-throttle lever designs or manual thrust setting procedures, compelling flight</u>

deck alerts may be acceptable in lieu of automatic thrust recovery of the operating engine to permit use of maximum go-around thrust for §25.121(d) compliance.

The group agreed that the added sentence clarified the fact that allowance for use of maximum go-around thrust for 25.121 (d) compliance, would depend on proposed OEM specific designs in case engine failure manual thrust recovery during go-around with RGA thrust or power is used.

- the guidance material for 21.a (5) and 21.b (5), 21.b(1) and (8) (for §25.145) have been updated to clarify when the maximum go-around thrust setting should be used for compliance.

Dissenting Position	**FTHWG Answer to the Dissenting Position**
AC 20(h)2(b) Crew workload assessment : Gulfstream: The proposed addition of paragraph 25.143(b)(4) and the associated guidance to include assessment of flight crew workload would be unique in Subpart B and not consistent with FAA authorizations for DER and AR delegates. Flight crew workload is addressed by Human Factors organizations in many OEMs and associated workload assessments involve multiple pilots, including operational representative pilots and FAA AEG pilots. In contrast, compliance with Subpart B is normally found by Flight Analysts and Flight Test Pilots and typically a subjective finding can be made by a single delegated or AA flight test pilot. Although pilot workload in a go-around may be a relevant concern for this tasking, the systems involved in assessing that workload, including flight director/HUD pitch guidance; auto-flight, auto-throttle and FMS interaction; etc. are not typically evaluated and thus not required to be conformed for a Subpart B Controllability TIA test. It is recommended that the FTHWG remove "flight crew workload" from the proposed 25.143(b)(4) paragraph and associated guidance, and instead recommend the FAA revise AC 25.1523-1 to specify that AEO go-around evaluations should be included for assessment of flight crew workload and risk of somatogravic illusion. Textron Aviation, TCCA, ANAC, Boeing concur with the Gulfstream dissent. This makes 7 votes in favor of the majority position and 5 votes not in favor.	The FTHWG group majority is to retain Appendix D reference for the workload assessment in the AEO go-around phase as introduced in CS 25 Amendment 21. Requested MoC for CS 25.143 (b) (4) is Flight Test. Appendix D provides guidance and explanatory material for the definition and assessment of workload useful to test crews involved in qualitative assessment of the required pilot skill to conduct AEO go-around. Possibly, even if Flight test crews would not be supported by dedicated test tools and/or qualified HF personnel during the 25.143 (b)(4) flight tests, they should be able, applying usual pilot and engineering judgment, to cover all Appendix D points, but: - *(b)(4) The degree and duration of concentrated mental and physical effort involved in normal operation and in diagnosing and coping with malfunctions and emergencies, and* - *(b)(10) Incapacitation of a flight-crew member whenever the applicable operating rule requires a minimum flight crew of at least two pilots.* These two particular "Appendix D" points would in any case be covered in other certification tests (typically these are assessed in MoC8 in the scope of Human Factors). Human Factor experts for the AEO go-around 25. 143 (b) (4) pilot workload assessment would be acceptable but it is not considered necessary (i.e. HF expert could cooperate with Flight Test department for the definition of the test scenarios for

	dimensioning and demanding go-around cases and they could be collecting data, observations and test pilot debriefs).
AC 20 (h) 2 (c) Guidance for go-around maneuvers 25.143(b)(4): Textron Aviation dissent: The performance limiting criteria, as proposed, are not a useful means to identify risk for somatogravic illusion. As mentioned in the proposed guidance, there are no scientifically demonstrated performance levels that ensure acceptable risk of somatogravic illusion. The discussion states that the risk of somatogravic illusion is high when encountering high longitudinal acceleration or combined values of pitch attitude, pitch rate and longitudinal acceleration. However, these concepts (primacy of longitudinal acceleration and effects of interrelated parameters) are not reflected in a simple list of performance limiting criteria, for which it is implied that if any one element is exceeded then mitigation should be put in place. Nearly all Part 25 airplanes are likely to exceed at least one of the criteria without an RGA. TxtAv supports the proposed flight test conditions to evaluate the risk for somatogravic illusion. However, the guidance to “duly justify” any potential exceedance of one of the criteria does not contribute to the evaluation and potentially distracts from a holistic evaluation of the controllability during an AEO go-around by focusing on performance criteria of questionable relevance. Since a realistic path to demonstrate a level of somatogravic illusion risk that does not need to be mitigated is not provided in the guidance, the guidance is unreasonably biased towards mitigation with an RGA system. The proposal has the potential to drive such a system into classes of airplanes which have not historically been identified as susceptible to somatogravic illusion thereby introducing unnecessary systems and operational complexity. TxtAv recommends that the current list of performance criteria be withdrawn until additional research can be conducted to support development of evaluation techniques that can more definitively generate results that correlate to the risk of somatogravic illusion.	The FTHWG group majority is to retain performance limiting criteria proposed as a means to identify risk for somatogravic illusion and added the following: *‘Note2: the numbers above should not be considered hard limits but a reference only.’* The FTHWG believes that the updated wording addresses Textron’s concern.

In support of the items above, TxtAv proposes alternate guidance for 25.143(b)(4) (refer to Attachment 18F) Gulfstream, ANAC and Boeing concur with the TxtAv dissent and support the alternate guidance proposed in Attachment 18F. This makes 8 votes in favor of the majority position and 4 votes not in favor.	

Recommendation

The FAA should adopt the harmonized standard and guidance. Further, the FAA should liaise with EASA, TCCA, and ANAC to ensure consistent implementation in their jurisdictions.

A. Rulemaking

1. What is the proposed action?

The FTHWG recommends changes to 14 CFR Part 25 paragraphs 25.143, 25.145. Further, the FTHWG recommends identical changes to similar paragraphs of the EASA certification standard CS-25, TCCA AWM 525, ANAC RBAC25.
In addition, FTHWG recommends associated changes to the relevant guidance material and that identical changes are made to the guidance published by the counterpart authorities.

The FTHWG has discussed the potential use of ATTCS (Automatic Takeoff Thrust Control System) as one particular type of RGA implementation that could be made available during Go-Around to help mitigate somatogravic illusions. The system limits the amount of thrust available when all engines are operating normally (AEO), which reduces the maximum acceleration and consequently would reduce the chances of somatogravic illusions during go-around. Furthermore, in case of an engine failure, the ATTCS promptly and automatically increases the thrust on the remaining engine(s), which guarantees adequate OEI climb performance.
In addition to the recommendations detailed in Attachments B, C and D the FTHWG recommends the FAA to coordinate with a group of Propulsion System specialists to create a new Appendix in order to support the use of ATTCS type implementations during go-around as a means of mitigating somatogravic illusions. These topics should be discussed further:

1) Explicit allowance for use of ATTCS type functions during the go-around phase.
   Note: ATTCS during go-around were already approved in some existing airplanes, albeit via Issue Papers.

2) Increase the allowable range between AEO and OEI thrust levels as required to balance the AEO mitigation for somatogravic illusions versus the OEI climb performance.
   Note: Current Appendix I restricts the difference between AEO and OEI to a maximum of 10%. Somatogravic illusion was not envisioned when Appendix I was introduced.

Refer to Attachment 18E for ‘Industry proposal for use of ATTCS as a mitigation for somatogravic illusion during go-around’.

2. What should the harmonized standard be?

The FTHWG believes that a single standard of airworthiness can be achieved. Attachment 18C (for AEO go-around) provides the FTHWG recommended Rulemaking text and presents the changes to existing regulatory paragraphs. FTHWG Comments and Rationale for adopting these changes are expressed in chapter ‘Consensus’ §2.

3. How does this proposed standard address the underlying safety issue?

The proposed standard will have the effect of ensuring a consistent safety standard for AEO go-around manoeuvres by requiring that it be shown during airworthiness certification that AEO go-arounds can be safely conducted without requiring exceptional piloting skill or alertness, and that the risk of excessive crew workload and the risk of somatogravic illusion are adequately addressed.

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

1) OEI go-around:

The FTHWG is not proposing any regulatory update, only a modified advisory material for paragraph 25.101(g) in AC 25-7C. The FTHWG recommendations contained in Attachments 18B consolidates several informal practices and provides a harmonized means of compliance that the group considers an increase in safety.
The new guidance will ensure that all future designs provide safe OEI go-around capability when operated in accordance with the AFM go-around procedures and scheduled airspeeds.

2) AEO go-around:

The current Part 25 regulations for AEO go-around do not specifically require it be shown that the airplane is safely controllable and maneuverable during an AEO go-around at high thrust-to-weight ratios. The proposed standard will increase safety by requiring it be shown that AEO go-arounds can be safely conducted without requiring exceptional piloting skill or alertness, and that the risk of excessive crew workload and the risk of somatogravic illusion are adequately addressed.

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

1) OEI go-around:

See above §4

2) AEO go-around:

The risk of excessive pilot workload and the risk of somatogravic illusion during high thrust-to-weight AEO go-arounds have only recently been identified as safety concerns. As such, current industry practice has been dependent on each manufacturer's history with in-service incidents or accidents.

Some manufacturers have developed and included designs that reduce thrust during AEO go-around to avoid applying excessive thrust, thereby providing more time to the flight crew to perform the required actions during go-around, and reduce the dynamics of the go-around to decrease the risk of somatogravic illusion associated with large longitudinal acceleration and excessive pitch attitudes. For manufacturers who have adopted such designs, the proposed standard is expected to maintain the same level of safety.

For designs that are not prone to generating excessive longitudinal acceleration or pitch attitudes in an AEO go-around, possibly due to existing automated systems and/or envelope limiting/protection systems, the additional demonstrations required by the proposed new standards are also not expected to result in significant increase in the level of safety. However, specific certification testing to ensure such systems provide sufficient mitigation for the identified risks of AEO go-arounds is expected to lead to an increase in safety in some cases.

Finally, for manufacturers who have not previously evaluated their designs for these identified AEO go-around risks and who do not currently have designs that include mitigations for high thrust-to-weight go-around conditions, it is expected that the proposed standard will increase the level of safety. The additional required demonstrations of acceptable pilot workload during AEO go-around and criteria for evaluating risk of somatogravic illusion may identify designs that exhibit characteristics similar to those involved in the incidents/accidents. In this case, mitigations would be needed to reduce the risk of such an event.

6. Who would be affected by the proposed change?

Manufacturers developing new or derivative transport category airplanes and other organizations (e.g. companies developing after-market improvements/upgrades).

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

Yes. It is recommended that the use of Reduced Thrust go-around procedures introduced in this report be reviewed by the Avionics, Human factors and Propulsion specialists to check it does not introduce any unintended consequences.

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 should be updated, with the Proposed changes to AC 25-7C in Attachment 18B (for OEI go around) and in Attachment 18D (for AEO go-around).

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

   For Harmonization, EASA, TCCA and ANAC advisory material should be updated in the same way and Special conditions /interpretative material guidance should be cancelled.

Economics

A. What is the cost impact of complying with the proposed standard (it may be necessary to get FAA Economist support to answer this one)?

1) OEI go-around:

The proposed advisory material in Attachment 18B includes new additional compliance tests to 25.101(g) (flight test, simulation or analysis depending on the case).

Although height loss demonstrations were already included in CS 25 Amendment 13 guidance material book 2 and FAA AC 25-7C already specifies that the missed approach procedure is to be demonstrated by test to be safe and easily executed by flight crews of average skill, this recommendation would revise the procedures used during demonstration and associated success criteria.

Although the proposed minimum trajectory for the OEI go-around is new, the proposed procedure identifies piloted (i.e. pilot–in–the loop) simulation as a satisfactory test in lieu of flight testing.

The proposed advisory material specifies that flight testing, simulation and/or analysis at a range of (WAT limit or simulated WAT limit) conditions should be conducted to assess that the go-around trajectory remains above the profile presented. This may involve additional testing and/or additional analysis and documentation effort beyond what is currently done for 25.101(g)(h) compliance.

The introduction of the minimum trajectory criterion has the potential to impact operations into high field elevations at elevated temperatures for future designs, but they are expected be minimal based on studies on the current designs. The FTHWG believes that it is the appropriate balance between safety and operational capability.

2) AEO go-around:

The proposed updates of Part 25 subpart B paragraphs in association with their updated AC 25-7C guidance include evaluations of the AEO go-around maneuver focused on workload and risk of somatogravic illusion, and mitigation of any excessive risk identified. This would be applicable for new Type certificate aircraft or some significant aircraft changes that would affect go-around aircraft capabilities.

For the OEMs, it may trigger additional investigation of management of go-around maneuver, and eventually the development and certification of mitigation means, which could include an RGA (Reduced Go-Around) function as an acceptable means of compliance. Nevertheless, this is not the only acceptable means of compliance and other (less expensive) means of compliance may be offered such as an appropriate thrust setting recommended to the crew via a dedicated AFM procedure.
According to the survey conducted by EASA RMT 0647 group and the economic impact estimated in NPA 2017-06, in case such function would have to be developed, the Non-Recurring Cost is estimated to several tens of millions euros (50 million euros can be taken as an order of magnitude).
Nevertheless, not all manufacturers would be impacted since some of them (e.g. Airbus, Boeing) have already this function available on their fleet.

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?

1) OEI go-around:

Some relevant aspects of the ICAO PAN-OPS/TERPS guidelines for runway construction and safety dealing with obstacle clearance were reviewed but a conclusion was made that this material was not addressing especially OEI go-around, but AEO go-around obstacle clearance only.

In 2018, ICAO is planning to publish guidance material for compliance with performance Standards and Recommended Practices in Annex 6 and Annex 8 in the new Doc 10064 Aeroplane Performance Manual. This manual is developed to combine guidelines on certification and operational requirements regarding airplane performance. It will contain recommendations to operators to consider obstacle analysis for go-around and balked landing, broadly in line with FAA AC 120.91. In particular, it is recommended to take into account the effect of speed changes on the vertical flight path. Guidance material illustrates a possible approach to such analysis.
The draft Aeroplane Performance Manual was reviewed by the FTHWG and was not found in contradiction with the recommended guidance material for OEI go-around as proposed in Attachment 18B of this report.

2) AEO go-around:

ICAO does not address somatogravic illusion mitigation when conducting a go-around. The proposed standard is not in contradiction with it.

Attachment 18A: Topic 18 Work Plan –Go Around Handling Qualities and Performance

1. What is the task?
Harmonization of Go Around regulation and material guidance: - based on current EASA material, establish the need for harmonized criteria for procedures, Handling Qualities and performance - if needed, establish criteria for height loss, trajectory, timing of climb gradient capability relevant or necessary for decision height down to CAT 2 operations - Establish the need to evaluate the draft EASA NPA regarding susceptibility to somatogravic illusions for Go-Around All engine Operative
2. Who will work the task?
The Flight Test Harmonization Working Group (FTHWG) will have primary responsibility for this task.
3. Why is this task needed? (Background information)
GAR One Engine Inoperative: EASA have provided guidance material since the early 2000's, CRI's to applicants, a generic CRI (Go-Around Performance Interpretative Material), and introduced AMC 25-101(g) in CS25 at Amendment 13. FAA does not. As compliance to this guidance may result in significant impact on aircraft configuration and/or procedures, harmonization of Go-Around material is desirable. GAR All Engine Operative: EASA is introducing a draft NPA -RMT 0647 that needs to be considered.
4. References (existing regulatory and guidance material, including special conditions, CRIs, etc.)
1) GAR OEI: CS25 Amendment 13, book 1 25.101g, 25.101(h), 25.119, 25. 121(d) and book 2 AMC CS25.101(g), NPA 2011-9 (p 13 & 33) and CRD 2011-9 - TCCA AC 525-009 - AC 25-7C § 17b7 – related to §121d), 101g), h) - p 74 - CS-AWO 243 - CAA/JAA CAI in the early 2000's on Embraer products - EASA generic CRI B-XX - TCCA CM on C-Series - Industry/Authority Working Papers from JAA Flight Study Group: FWP 623-1 dated Jan 18, 1999, FWP 731-1 dated Aug 8, 2002, FWP 479 dated 1994 2) GAR AEO: - EASA draft NPA 2017-06 (from EASA RMT.0647) related regulatory & guidance to 25.143, 25. 145 and Appendix Q (Steep Approach and Landing)
5. Working method
It is envisioned that 3 face-to-face meetings over a period of 12 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
Regulations noted in Section 4 above, although this is primarily a means of compliance
8. Additional information
None

Attachment 18B: Recommended Guidance Material- OEI go-around

25.101 - For reference only (no change):

(f) Unless otherwise prescribed, in determining the accelerate-stop distances, takeoff flight paths, takeoff distances, and landing distances, changes in the airplane's configuration, speed, power, and thrust, must be made in accordance with procedures established by the applicant for operation in service.

(g) Procedures for the execution of balked landings and missed approaches associated with the conditions prescribed in §§ 25.119 and 25.121(d) must be established.

(h) The procedures established under paragraphs (f) and (g) of this section must—
(1) Be able to be consistently executed in service by crews of average skill;
(2) Use methods or devices that are safe and reliable; and
(3) Include allowance for any time delays, in the execution of the procedures, that may reasonably be expected in service.

AC 25-7C (markup):
Paragraph 17.b
(7) Section 25.121(d) permits the use of a climb speed established in connection with normal landing procedures, but not more than 1.4 V_{SR}. Section 25.101(g) requires that the procedures for the execution of missed approaches associated with the conditions prescribed in § 25.121(d) must be established. Consequently, the speeds and flap configuration used to show compliance with the minimum climb gradient requirements of § 25.121(d) need to be consistent with the speeds and flap configurations specified for go-around in the AFM operating procedures. ~~In order to demonstrate the acceptability of recommended procedures, the applicant should conduct go-around demonstrations to include a weight, altitude, temperature (WAT)-limited or simulated WAT-limited thrust condition. In accordance with § 25.101(h), the established procedures must-~~

~~(a) Be able to be consistently executed in service by crews of average skill,~~
~~(b) Use methods or devices that are safe and reliable, and~~
~~(c) Include allowance for any time delays in the execution of the procedures that may reasonably be expected in service.~~

Proposed new 25.101(g) guidance (in place of AMC 25.101(g)) for AC25-7C in Para 9:

a. Explanation - Go-around. Section 25.101(g) requires that procedures for the execution of balked landings and missed approaches associated with the conditions prescribed in §§ 25.119 and 25.121(d) must be established. And as required by § 25.1587(b)(4), each AFM must contain the procedures established under § 25.101(g), including any relevant limitations or information in the form of guidance material. The landing climb gradient determined under § 25.119 conditions, the approach climb gradient determined under § 25.121(d) conditions, and the additional operating limitations regarding maximum landing weight established in accordance with § 25.1533(a)(2) must be consistent with the established balked landing and missed approach procedures (§ 25.101(g)) provided in the AFM. In order to demonstrate the acceptability of recommended missed approach and balked landing procedures, the applicant should conduct demonstrations (by flight test or pilot-in-the-loop simulator test) to include a one engine inoperative go-around at a weight, altitude, temperature (WAT)-limited or simulated WAT-limited thrust condition.

The applicant should conduct the demonstrations at WAT-limited conditions that result in the largest height loss and/or longest horizontal distance to accelerate to the scheduled approach climb speed. Alternatively, the applicant may conduct testing at simulated WAT-limited conditions (with reduced thrust on the operating engine) and use the resulting time delays for each crew action in subsequent off-line simulation/analysis in accordance with the Procedures below. Although compliance with 25.101(g)(h) and 25.121(d) are not directly linked with the criteria for approval of weather minima for approach (AC 120-29A), the minimum decision height for initiating a go-around is dependent upon the weather minima to be approved. In addition, a higher climb gradient and associated lower WAT limited landing weight may be associated with CAT II operations. As such, if CAT II weather minima approval is expected, the applicant should conduct the go-around demonstration and/or analysis consistent with both CAT I and II operations for the associated decision height and WAT-limited thrust condition (or a critical combination thereof).

b. Procedures. The go-around demonstration specified in paragraph a. of this section can be conducted at an altitude above the normal decision height/altitude (for test safety), with the height loss in the maneuver used to show that ground contact prior to the runway threshold would not occur if the maneuver was initiated at the decision height/altitude. Flight testing, simulation and/or analysis at a range of (WAT limit or simulated WAT limit) conditions throughout the approved envelope should be conducted to assess height loss relative to the decision height/altitude consistent with criteria for the weather minima to be approved (or higher as constrained by AFM limitation). At least one flight test or pilot-in-the-loop simulator test should be conducted at a WAT-limited condition to assess the OEI go-around procedure and establish time delays used for any subsequent analysis/simulation.

In addition, the assessment of the go-around procedure should include consideration of horizontal distance (based upon minimum go-around trajectory) needed to establish the minimum engine-out climb gradient required by § 25.121(d) or higher gradient as required by specific weather minima operational criteria. It should be shown by flight test, simulation and/or analysis that the airplane would remain above the profile illustrated in Figure 9-1 when the go-around is evaluated at the critical WAT limit condition (up to structural maximal landing weight) and flown in accordance with the OEI go-around procedure.

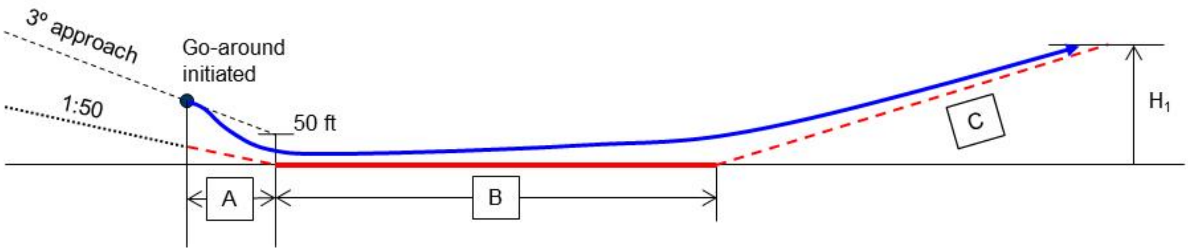
This provides a minimum design standard trajectory for a missed approach with one engine inoperative and does not constitute a means to assure obstacle clearance. It does not preclude additional missed approach procedures that may be developed to satisfy operational requirements, including special or complex missed approach path requirements. The operator should seek approval from their civil aviation authority to use the additional procedures and data.

(1) In accordance with § 25.101(h), the established procedures for executing balked landings and missed approaches must-
   (a) Be able to be consistently executed in service by crews of average skill,
   (b) Use methods or devices that are safe and reliable, and
   (c) Include allowance for any time delays in the execution of the procedures that may reasonably be expected in service (including recovery of full go-around power or thrust if equipped with a Reduced Go-Around (RGA) power or thrust system that requires manual override as discussed in paragraph 20.h.4 of this AC), but should not be less than 1 second between successive crew actions, except for movements of the primary flying controls.

(2) The flight test demonstration(s), simulation and/or analysis should be made with:
   (a) All engines operating and the power or thrust initially set for a 3 deg approach, and the configuration and final approach airspeed consistent with the all engine operating landing procedure (not more than V_{REF} + 5 kt) in zero wind conditions,
   (b) Application of available go-around power or thrust at the selected go-around height (initially the RGA power or thrust level, if so equipped, followed by either automatic or manual selection of full go-around thrust in accordance with the established missed approach and engine failure AFM procedures) with simultaneous failure of the critical engine (or with simulated engine failure, including the effects on dependent systems), and

(c) The high lift system, pitch attitude, engine/propeller controls and airspeed adjusted to achieve the conditions consistent with § 25.121(d), in accordance with the established missed approach and engine failure AFM procedures. The landing gear should be selected to the 'up' position only after positive rate of climb is achieved. If use of automatic features (autopilot, auto-throttle, flight director, etc.) is included in the procedure, these features should be considered during the demonstration.

Figure 9-1. Trajectory Assessment for OEI Go-around



Segment A: From the initiation of go-around at the decision height/altitude to the runway threshold – remain above a 1:50 (2.0%) plane extended to the runway threshold for clearance of airport obstacles (reference AC 150/5300-13A Change 1, Chapter 3, para 308).

Segment B: From the runway threshold plus a distance defined by 40 seconds * V_{T_appr}, not more than a distance equal to the table below – remain above ground height.

Field Elevation (ft)	Distance (ft)
0-10,000	10,000
> 10,000	= Field Elevation

Segment C: A straight line from the end of Segment B at ground height with a gradient defined by §25.121(d)(1) or higher gradient as required by specific weather minima operational criteria, up to a height, H_1 – remain above the line.

Where:

V_{T_appr}: the true airspeed for the normal recommended AEO approach speed in zero wind at the flight condition being assessed (not more than V_{REF} + 5 KCAS).

H_1: the height above the runway elevation where the airplane has achieved the approach climb configuration and stabilized on the approach climb speed outside of ground effect (1x the wing span), not less than the height at which the go-around was initiated.

Attachment 18C: Recommended Rulemaking Text- AEO go-around

Colours for Part 25 Rule Changes:
Red for Topic18- Go-around changes
Green for changes coming from Topic 1- Flight Envelope Protection (High Angle of Attack Protected airplanes)

Controllability and Manoeuvrability

Amend § 25.143 as follows:

25.143 General

(a) The airplane must be safely controllable and manoeuvrable during:

(1) ~~T~~take-off;
(2) ~~C~~climb;
(3) ~~L~~level flight;
(4) ~~D~~descent; ~~and~~
(5) ~~Landing~~ approach and go-around; and~~.~~
(6) approach and landing.

(b) It must be possible to make a smooth transition from one flight condition to any other flight condition without exceptional piloting skill, alertness, or strength, and without danger of exceeding the airplane limit-load factor under any probable operating conditions, including: –

(1) The sudden failure of the critical engine~~.~~;

(2) For airplanes with three or more engines, the sudden failure of the second critical engine when the airplane is in the en route, approach, or landing configuration and is trimmed with the critical engine inoperative;~~and~~

(3) Configuration changes, including deployment or retraction of deceleration devices~~.~~; and

(4) Go-around maneuvers with all engines operating. The assessment must include, in addition to controllability and maneuverability aspects, the flight crew workload and the risk of somatogravic illusion

Amend § 25.145 as follows:

25.145 Longitudinal control

(a) It must be possible at any point between the trim speed prescribed in §25.103(b)(6) and stall identification (as defined in §25.201(d)), or the angle of attack achieved at full aft control input if compliance is shown with §§25.202 and 25.204)to pitch the nose downward so that the acceleration to this selected trim speed is prompt with: –

(1) ~~T~~the airplane trimmed at the trim speed prescribed in §25.103(b)(6);
(2) ~~T~~the most critical landing gear ~~extended~~ configuration;
(3) ~~T~~the wing-flaps (i) retracted and (ii) extended; and
(4) engine thrust or ~~P~~power (i) off and (ii) at maximum go-around setting ~~continuous power on the engines~~.

(…)

(e) It must be possible to maintain adequate longitudinal and speed control under the following conditions without exceptional piloting skill, alertness, or strength, and without danger of exceeding the airplane limit-load factor and while maintaining adequate stall margin throughout the maneuver:

(1) Starting with the airplane in each approved approach and landing configuration, trimmed longitudinally and with thrust or power setting per §25.161(c)(2), perform a go-around, transition to the next flight phase and level-off at the desired altitude:

(i) with all engines operating and the thrust or power controls initially moved to the maximum go-around power or thrust setting;

(ii) with the configuration changes, and thrust or power management as per the approved operating procedures or conventional operating practices; and

(iii) with any practicable combination of Flight Guidance/Autothrust-throttle/Autopilot to be approved, including manual.

(2) Reasonably expected variations in service from the established approach, landing, and go-around procedures for the operation of the airplane must not result in unsafe flight characteristics during go-around.

Attachment 18D: Recommended Guidance Material- AEO go-around

Colours for AC 25-7C Changes: Red for Topic18- Go-around changes Green for changes coming from Topic 1- Flight Envelope Protection (High Angle of Attack Protected airplanes)

Amend AC 25-7C as follows:

Add new text in Paragraph 16 to address AEO go-around with an RGA:

16. Landing Climb: All-Engines-Operating - § 25.119.

a. Explanation. Section 25.119(a) states that the engines are to be set at the power or thrust that is available 8 seconds after starting to move the power or thrust controls from the minimum flight idle position to the go-around power or thrust setting. Use the procedures given below for the determination of this maximum power or thrust for showing compliance with the climb requirements of § 25.119.

For airplanes equipped with a Reduced Go-Around (RGA) thrust or power system (see paragraph 20.h.(4)(f)), the climb requirements specified in §25.119 are applicable with the RGA system active. During the determination of the maximum power or thrust specified in paragraph 16.b, the power or thrust controls shall be moved to the RGA power or thrust setting. This is consistent with an AFM all-engines-operating go-around procedure which recommends the use of a RGA system (see RGA guidance in §25.143). In exceptional circumstances such as in the presence of windshear or of unplanned obstacles, the crew may elect to use go-around power or thrust that exceed the RGA setting. However, the applicant is not required to provide AFM climb gradient performance for this situation and the test procedure in paragraph 16.b is not applicable in this case.
If an AFM go-around procedure is approved by the authority to use power or thrust above the RGA setting, then the applicant shall use the test procedure in paragraph 16.b with this higher power or thrust setting. The climb requirements of §25.119 will then apply at the higher power or thrust setting.

b. Procedures.
……….

Amend AC 25-7C Paragraph 20 as follows:

20. General - § 25.143.

a. Explanation. The purpose of § 25.143 is to verify that any operational maneuvers conducted within the operational envelope can be accomplished smoothly with average piloting skill and without encountering a stall warning or other characteristics that might interfere with normal maneuvering, or without exceeding any airplane structural limits. Control forces should not be so high that the pilot cannot safely maneuver the airplane. Also, the forces should not be so light that it would take exceptional skill to maneuver the airplane without over-stressing it or losing control. The airplane response to any control input should be predictable to the pilot.
(….)

b. General Test Requirements.

(1) Compliance with § 25.143 (a) through (g) is primarily a qualitative determination by the pilot during the course of the flight test program. The control forces required and airplane response should be evaluated during changes from one flight condition to another and during maneuvering flight. The forces required should be appropriate to the flight condition being evaluated. For example, during an approach for landing or a go-around, the forces should be light and the airplane responsive in order that adjustments in the flight path can be accomplished with a minimum of workload. In cruise flight, forces and airplane response should be such that inadvertent control input does not result in exceeding limits or in undesirable maneuvers. Longitudinal control forces should be evaluated during accelerated flight to ensure a positive stick force with increasing normal acceleration. Forces should be heavy enough at the limit load factor to prevent inadvertent excursions beyond the

design limit. Sudden engine failures should be investigated during any flight condition or in any configuration considered critical, if not covered by another section of part 25. Control forces considered excessive should be measured to verify compliance with the maximum control force limits specified in § 25.143(d). Allowance should be made for delays in the initiation of recovery action appropriate to the situation.
(….)

c. Controllability Following Engine Failure. Section 25.143(b)(1) requires the airplane to be controllable following the sudden failure of the critical engine.
(…)
d. Pilot Induced Oscillations (PIO).
(…)
e. Maneuvering Characteristics - §25.143 (g).
(…)
f. Thrust or Power Setting for Maneuver Capability Demonstrations.
(…)
g. General Requirements for Envelope Protection Functions- §25.144.

h. Go-around Maneuvers – 25.143 (b)(4)

(1) Explanation

When full thrust or power is applied during a go-around, an excessive level of performance (rate of climb, accelerations) may be reached very quickly and may make it difficult for the flight crew to undertake the actions required during a go-around, especially in an environment that is constrained (due to Air Traffic Control instructions, operational procedures, etc) and rapidly changing. This level of performance can also generate acceleration levels (in particular, forward linear accelerations) that could lead to spatial disorientation for the flight crews (e.g. somatogravic illusion), in particular when combined with reduced visibility conditions and a lack of monitoring of primary flight parameters, such as pitch attitude.

Accidents and incidents have occurred during or after go-around where somatogravic illusions have led flight crews to make inappropriate nose-down inputs, leading to an aircraft upset, a loss of control or a deviation from the normal go-around flight path, and in some cases, controlled flight into terrain with catastrophic consequences.

Other accidents resulting in loss of control were due to excessive pitch attitudes combined with the flight crew's inadequate awareness of the situation.

The risk is higher on airplanes that have a large operational range of thrust over weight ratios, in particular for twin-engine aeroplanes and those with long-range capabilities.

(2) Special Considerations: Criteria for assessing the Go-around manoeuvre risk with respect to somatogravic illusion and flight crew workload

(a) Somatogravic illusion

It is considered that the risk of somatogravic illusion is high when encountering high longitudinal acceleration or combined high values of pitch attitude (nose-up), pitch rate and longitudinal acceleration, associated with a loss of outside visual references.

(b) Workload

In order to provide sufficient time to the flight crew to manage its tasks, and therefore keep their workload at a reasonable level, longitudinal acceleration and vertical speed may need to be constrained. The assessment of the workload should be performed considering the basic workload functions described in Appendix D of 14 CFR Part-25.

(c) Risk assessment and mitigation means

There are no scientifically demonstrated aeroplane performance limits to ensure that the risks of somatogravic illusions and excessive workloads remain at acceptable levels. However, the following criteria should not be exceeded during recommended go-around maneuver:

— a pitch rate value above 4 degrees per second,

— a pitch attitude above 20 degrees nose-up,

— an energy level corresponding to either:

- a vertical speed of 3 000 ft/min at constant calibrated airspeed,
- a climb gradient of 22 % at constant calibrated airspeed, or
- a level flight longitudinal acceleration capability of 7.8km/h(4.2kt) per second.

Note 1: these boundaries should not affect operational performance, as they are considered to be beyond the operational needs for a go-around.

Note 2: the numbers above should not be considered hard limits but a reference only.

Design mitigation means should be put in place to reduce the risk at an acceptable level. These means should:

— provide a robust method to reduce the risk identified, and

— be used during recommended go-around procedures.

A reduced go-around (RGA) thrust or power function is considered as an acceptable mitigation means (refer to paragraph 20.h.(4) below).

Alternatively, exceeding any one of the above criteria should be duly justified by the applicant and accepted by the Authority.

(3) Procedures : Go-around evaluation

Go-around maneuvers should be performed during flight testing in order to verify, in addition to the controllability and maneuverability aspects, that the flight crew workload and the risk of a somatogravic illusion are maintained at an acceptable level (for an acceptable level of risk of a somatogravic illusion, refer to paragraph 20.h.(2)(c) of this AC). The go-around maneuvers should be performed with all engines operating (AEO) and for each approved landing configuration as per the recommended AFM go-around procedure:

— with the most unfavorable and practicable combination of center of gravity position and weight approved for landing,

— with any practicable combination of flight Guidance/autothrust-throttle/autopilot to be approved, including manual,

— with a level-off altitude 1000 ft above the go-around initiation altitude.

(4) Possible mitigation means : Implementation of a reduced go-around (RGA) thrust or power function

The applicant may provide an RGA thrust or power function for use when the flight crew initiates a go-around. The function should operate with any practicable combination of the flight guidance/autothrust-throttle/autopilot modes to be approved for operation, including manual modes.

This function should limit the engine thrust or power applied and maintain the performance of the aeroplane (in particular, its rate of climb) at a level that:

— is not less than the minimum required performance compatible with the operational needs and the flight crew workload during this phase; and

— reduces the flight crew's risk of suffering a somatogravic illusion.

This thrust or power reduction function may be available either automatically or by manual selection.
In any case, acceptable procedure(s) should be available in the airplane flight manual (AFM), and the recommended go-around procedure should be based on RGA thrust or power setting.

Note: When a reduced go-around thrust function is installed or a specific power setting is recommended by procedure, the applicant should still use the most critical thrust or power within the range of available go-around thrust or power when showing compliance with the Part-25 specifications.

(a) Design target
RGA functions with a design target of 2000 ft/min rate of climb capability have been accepted by the Authority.

(b) Cockpit indications and information to the flight crew
In automatic mode, information that thrust or power is reduced in the RGA mode should be indicated to the flight crew.
In manual mode, the thrust level tables should be made available to the flight crew.

(c) Evaluation
An evaluation of the go-around maneuver with the RGA thrust or power function should be conducted following the recommendations of paragraph 20.h.(3) above.

(d) Thrust or power mode command
It should be possible for the flight crew, at any time and without delay, to select and apply the full go-around thrust or power.
The applicant should provide specific procedures for which full thrust or power may be required, such as 25. 121 (d) minimum performance, windshear alert procedures, TCAS alert procedures, etc.

(e) Engine failure during go-around with RGA thrust or power

When an engine failure occurs during a go-around performed with active RGA thrust or power, if the required thrust or power from the remaining engine(s) to achieve adequate performance level cannot be applied automatically, a warning alert to the flight crew is required to prompt them to take the necessary thrust or power recovery action. For non-moving auto-throttle lever designs or manual thrust setting procedures, compelling flight deck alerts may be acceptable in lieu of automatic thrust recovery of the operating engine to permit use of maximum go-around thrust for §25.121 (d) compliance.

The procedure for the recovery of the engine thrust or power setting must be demonstrated to be acceptable in terms of the detection of the situation by the pilot and the required actions in a high-workload environment.
The following items should be evaluated:

- the timeliness of achieving the minimum required performance;
- flight crew awareness (indications, alerting…);
- flight crew actions (commands);
- the flight crew workload in general.

(f) Performance published in the AFM for RGA thrust or power
The climb performance required by §25.119 (in a landing climb, i.e. with all engines operating) should be based on the actual RGA thrust or power available (applied by following the recommended AFM procedure).
The climb performance required by §25.121 (in an approach climb, i.e. with one engine inoperative) should be based on:

- either the RGA thrust or power available, if no thrust or power recovery is implemented,
- or the go-around thrust or power available after the application of the thrust or power recovery action (either automatically, or manually after an alert is triggered). For non-moving auto-throttle

lever designs or manual thrust setting procedures, compelling flight deck alerts may be acceptable in lieu of automatic thrust recovery of the operating engine to permit use of maximum go-around thrust for §25.121 (d) compliance.

Amend AC 25-7C Paragraph 21 as follows:

21. Longitudinal Control - § 25.145.

a. Explanation.

(1) Section 25.145(a) requires that there be adequate longitudinal control to promptly pitch the airplane nose down from at or near the stall, or the angle of attack achieved at full aft control input (the AOA limit) when a High Angle-of-Attack Limiting Function is installed and compliance is shown with §§ 25.202 and 25.204, to return to the original trim speed. The intent is to ensure that there is sufficient pitch control for a prompt recovery if inadvertently slowed to the minimum achievable airspeed, including to the point of stall identification if normally achievable. Although this requirement must be met with engine thrust or power off and at maximum go-around setting ~~continuous thrust or power~~, there is no intention to require stall demonstrations with thrust or power above that specified in § 25.201(a)(2) or § 25.202(b)(2) as appropriate. Instead of performing a full stall at maximum go-around ~~continuous power or~~ thrust or power setting with airplanes for which compliance is shown to §25.207, compliance with § 25.145(a) may be assessed by demonstrating sufficient static longitudinal stability and nose down control margin when the deceleration is ended at least one second past stall warning during a one knot per second deceleration. The static longitudinal stability during the maneuver and the nose down control power remaining at the end of the maneuver must be sufficient to assure compliance with the requirement.

(2) Section 145(b)
(…)
(3) Section 145(c)
(…)
(4) Section 145(d)
(…)

(5) Section 145(e) requires that it must be possible to maintain adequate longitudinal and speed control during the all-engine-operating go-around maneuver without exceptional piloting skill, alertness, or strength, and without danger of exceeding the aeroplane limit-load factor and while maintaining adequate stall margin throughout the maneuver. The objective is to assess, in particular, the combined effects of thrust or power application and a nose-up trim pitching moment.

(a) The applicant should perform the evaluation throughout the range of thrust-to-weight ratios to be certified. This range should include, in particular, the highest thrust-to-weight ratio for the all-engines-operating condition, with the airplane at its minimum landing weight, all engines operating and the maximum thrust or power at the go-around setting.
The evaluation should show adequate:

- pitch control (i.e. no risk of excessive pitch rate or attitude, maintaining an adequate stall margin throughout the maneuver, no excessive overshoot of the level-off altitude), and
- speed control (i.e. no risk of speed instability or exceedance of V_{FE} with the wing-flaps extended and V_{LE} with the landing gear extended).

Refer also to AC 25.1329-1C paragraph 99.d(4), which provides guidance related to the demonstration of the flight guidance system go-around mode.

(b) The applicant must evaluate reasonably expected variations in service from the established approach, landing and go-around procedures and ensure that they do not result in unsafe flight characteristics during a go-around.

It is expected that these variations may include:

1 non-stabilized speed conditions prior to the initiation of a go-around (e.g. approach speed - 5 kt), and

2 adverse pitch trim positions:

- in manual mode with a manual pitch trim, a pitch trim positioned for the approach or landing configuration, and kept at this position during the go-around phase; and
- in autopilot or manual mode with an automatic pitch trim function: the most adverse position that can be sustained by the autopilot or automatic pitch trim function, limited to the available protecting/limiting features or alert (if credit can be taken for it).

The applicant should perform these demonstrations by conducting go-around maneuvers in flight or during simulator test programs.

b. Procedures. The following test procedures outline an acceptable means for demonstrating compliance with § 25.145. These tests may be conducted at an optional altitude in accordance with § 25.21(c). Where applicable, the conditions should be maintained on the engines throughout the maneuver.

(l) Longitudinal control recovery, § 25.145(a).

(a) Configuration:

1 Maximum weight, or a lighter weight if more critical.
2 Critical c.g. position.
3 The most critical Landing gear ~~extended~~ configuration.
4 Wing flaps retracted and extended to the maximum landing position.
5 Engine power or thrust at idle and maximum go-around setting ~~continuous~~.

(b) Test procedure:

1 The airplane must be trimmed at the speed for each configuration as prescribed in § 25.103(b)(6). The airplane should then be decelerated at 1 knot per second with wings level. For tests at idle power or thrust, the applicant must demonstrate that the nose can be pitched down from any speed between the trim speed and the stall identification or the AOA limit if a High Angle-of-Attack Limiting Function is installed and compliance is shown with §§ 25.202 & 25.204. Typically, with airplanes for which compliance is shown to § 25.201, the most critical point is at the stall when in stall buffet. The rate of speed increase during the recovery should be adequate to promptly return to the trim point. Data from the stall characteristics testing (§25.201) or high AOA handling demonstrations (§25.202), as appropriate, can be used to evaluate this capability at the stall. For tests at maximum go-around thrust or power setting ~~continuous power or~~, the maneuver need not be continued for more than one second beyond the onset of stall warning with airplanes for which compliance is shown to § 25.207. However, the static longitudinal stability characteristics during the maneuver, and the nose down control power remaining at the end of the maneuver, must be sufficient to assure that a prompt recovery to the trim speed could be attained if the airplane is slowed to the point of stall identification.

(2) Longitudinal control, flap extension, §145 (b)(1).
(…)
(3) Longitudinal control, flap retraction, § 25.145(b)(2) & (3).
(…)
(4) Longitudinal control, power or thrust application, § 25.145(b)(4) & (5).
(…)
(5) Longitudinal control, airspeed variation, § 25.145(b)(6).
(…)
(6) Longitudinal control, flap retraction and power or thrust application, § 25.145(c).
(…)
(7) Longitudinal control, out-of-trim takeoff conditions, §§ 25.107(e)(4) and 25.143(a)(1).
(…)

(8) Longitudinal control- go-around, §25.145 (e)

(a) Configuration :
1 Minimum landing weight expected in operation.
2 Critical c.g. position.
3 Each approved approach and landing flap position.
4 Landing gear extended.
5 Engine power or thrust per §25.161(c)(2) for V_{REF}
6 Pitch trim set in the most adverse position expected for approach and landing

(b) Test Procedure: Starting with the airplane in a wings-level descent, perform a go-around, transition to the next flight phase and level-off at the desired altitude:
1 with all engines operating and the thrust or power controls moved to the maximum go-around power or thrust setting;
2 with the configuration changes, as per the approved operating procedures or conventional operating practices; and
3 with any practicable combination of Flight Guidance/Autothrust-throttle/Autopilot to be approved, including manual.
4 Repeat the test at 5 knots below the normal approach or V_{REF} airspeed.

It must be possible to maintain adequate longitudinal and speed control during the all-engine-operating go-around maneuver without exceptional piloting skill, alertness, or strength, and without danger of exceeding the aeroplane limit-load factor and while maintaining adequate stall margin throughout the maneuver.

Amend AC 25-7C Paragraph 231 as follows:

231. Criteria For Approval Of Steep Approach To Landing.

a. Applicable Regulations . Sections 25.119, 25.121, 25.125, and 25.143.
(...)
b. Explanation.
(...)
c. General Criteria.
(...)

d. Test Conditions For Reasonably Expected Variations In Approach Speed and Path Angle.

(1) The following additional criteria should be applied to show that the airplane is safely controllable and maneuverable during landing (§ 25.143(a)(6~~5~~)).
(…)
(2) Compliance with § 25.143(b) ~~(1)~~ should be assessed as follows: Demonstrate that the airplane can both safely land and safely transition to a go-around with all engines and following a failure of the critical engine at any point in the approach under the following conditions:
(a) The steepest approach angle for which approval is sought;
(b) The V_{REF} established for a steep approach; and
(c) The most critical combination of weight and c.g; and
(d) For propeller powered airplanes, the propeller of the inoperative engine should be in the position it would normally assume without any action taken by the pilot following an engine failure.

Attachment 18E: Industry proposal for use of ATTCS as a mitigation for Somatogravic Illusion during go-around

1) What is ATTCS?

ATTCS means Automatic Takeoff Thrust Control System. It is presented in 14 CFR Part 25 Appendix I as an "installation of an engine power control system that automatically resets thrust or power on operating engine(s) in the event of any one engine failure during takeoff."

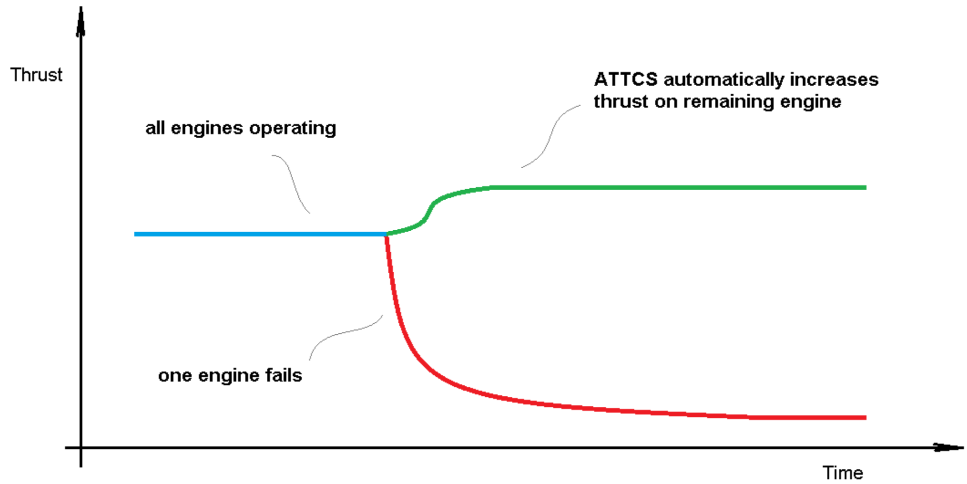


Figure 1 – Example of ATTCS implementation

Although Appendix I discusses only "Takeoff" explicitly, in many airplanes this type of function is also available during go-around. A typical difference between Takeoff and Go-Around implementations is that ATTCS can be switched "ON" or "OFF" prior to takeoff (in order to optimize the takeoff performance when limited by minimum control speeds) whereas for go-around ATTCS is always "ON".

2) How is ATTCS relevant for the Somatogravic Illusion discussion?

As described above ATTCS is a type of implementation that limits the amount of engine thrust available for go-around when all engines are operating normally. Limiting AEO thrust is exactly what is required from other types of implementations – like RGA for instance – to help limit parameters associated with somatogravic illusion, such as acceleration and rate of climb.

In addition, ATTCS acts promptly and automatically to increase thrust in the remaining engine(s) if one engine fails. AEO go-around performance is calculated with AEO thrust levels; OEI go-around performance and V_{MCL} are calculated with ATTCS thrust levels. Therefore, any concerns regarding engine failure cases, flight crew actions and workload and AFM information are already covered by this type of implementation.

3) What else do we need to promote the use of ATTCS type implementations as a means of mitigating somatogravic illusions during go-around?

Currently, Part 25 Appendix I Section I25.4 reads as follows:

"[The initial takeoff thrust or power setting on each engine at the beginning of the takeoff roll may not be less than any of the following:

(a) Ninety (90) percent of the thrust or power set by the ATTCS (the maximum takeoff thrust or power approved for the airplane under existing ambient conditions);

(b) That required to permit normal operation of all safety-related systems and equipment dependent upon engine thrust or power lever position; or

(c) That shown to be free of hazardous engine response characteristics when thrust or power is advanced from the initial takeoff thrust or power to the maximum approved takeoff thrust or power.]"

The issue with the minimum of 90% AEO thrust levels as compared with maximum OEI thrust levels as specified above is that it limits the potential benefit of ATTCS as a means of mitigating somatogravic illusion. Given that RGA functions have been found acceptable when designed to target no more than 2000 ft/min of rate of climb during AEO go-around, a similar ATTCS implementation could require more than 10% spread between AEO and OEI thrust levels in order to achieve the same result (depending on the configuration and type of aircraft).

The NPRM that introduced Appendix I provides the following explanation for the 10% cap between AEO and OEI thrust levels:

"The 90 percent thrust setting limit assures that the all-engine performance is not significantly degraded and that a minimum level of performance is available if an engine and ATTCS failure occur simultaneously."

Although the rationale above makes sense as a trade-off between a new failure condition introduced by the ATTCS itself and the function original intents, the following should also be considered:

Apparently, the use of ATTCS as a means of mitigating the risk of somatogravic illusion was not factored in the decision of introducing the 10% cap;
Modern designs (of airplanes, engines and FADEC) are such that the failure of one engine combined with the failure of the ATTCS on the remaining engine(s) is an extremely improbable scenario (< $1.0E^{-9}$);
Appendix I itself, on section I25.3 (b), already specifies that *"The concurrent existence of an ATTCS failure and an engine failure during the critical time interval must be shown to be extremely improbable";*
Expanding on the above, in recent years these implementations have evolved to the point that modern designs can take certification credit of Thrust Asymmetry Compensation and similar functions that rely on the correct and timely detection of an engine failure during critical phases of flight.

Based on the above, it is recommended to allow the use of ATTCS type functions for go-around with all-engine thrust lower than 90% of the ATTCS go-around thrust.

Attachment 18F: Alternate guidance for go-around maneuvers 25.143(b)(4)

Textron Aviation dissent and propose the following alternate proposal regarding AC 20 (h) 2 (c) Guidance for go-around maneuvers 25.143(b)(4)

Relevant Proposed Guidance:

(2) Special Considerations: Criteria for assessing the Go-around manoeuvre risk with respect to somatogravic illusion ~~and flight crew workload~~

…

(a) Somatogravic illusion

It is considered that the risk of somatogravic illusion is high when encountering high longitudinal acceleration or combined high values of pitch attitude (nose-up), pitch rate and longitudinal acceleration, associated with a loss of outside visual references.

~~**(b) Workload**~~

~~In order to provide sufficient time to the flight crew to manage its tasks, and therefore keep their workload at a reasonable level, longitudinal acceleration and vertical speed may need to be constrained. The assessment of the workload should be performed considering the basic workload functions described in Appendix D of FAR-25.~~

~~**(c) Risk assessment and Mitigation means**~~

~~There are no scientifically demonstrated aeroplane performance limits to ensure that the risks of somatogravic illusions and excessive workloads remain at acceptable levels. However, the following criteria should not be exceeded during standard go-around maneuver:~~

~~— a pitch rate value above 4 degrees per second,~~

~~— a pitch attitude above 20 degrees nose-up,~~

~~— an energy level corresponding to either:~~

- ~~a vertical speed of 3 000 ft/min at constant calibrated airspeed,~~
- ~~a climb gradient of 22 % at constant calibrated airspeed, or~~
- ~~a level flight longitudinal acceleration capability of 7.8km/h(4.2kt) per second.~~

~~Note1: these boundaries should not affect operational performance, as they are considered to be beyond the operational needs for a go-around.~~

~~Note 2 : the numbers above should not be considered hard limits but a reference only.~~

~~Design mitigation means should be put in place to reduce the risk at an acceptable level. These should:~~
Design mitigations may be put in place to reduce risk from somatogravic illusion to an acceptable level. Any needed design mitigations should:

— provide a robust method to reduce the risk identified, and

— be used during standard go-around procedures.

A reduced go-around (RGA) thrust or power function is considered as an acceptable means of mitigation (refer to paragraph 20.h.(4) below).

~~Alternatively, exceeding any one of the above criteria should be duly justified by the applicant and accepted by the Authority.~~

(3) Procedures : Go-around evaluation

~~Go-around maneuvers should be performed during flight testing in order to verify, in addition to the controllability and manoeuvrability aspects, that the flight crew workload and the risk of a somatogravic illusion are maintained at an acceptable level (for an acceptable level of risk of a somatogravic illusion, refer to paragraph 20.h.(2)(c) of this AC).~~ ~~The~~ Go-around maneuvers should be performed with all engines operating (AEO) and for each approved landing configuration as per the standard AFM go-around procedure:

— with the most unfavourable and practicable combination of centre of gravity position and weight approved for landing,

— with any practicable combination of flight Guidance/autothrust-throttle/autopilot to be approved, including manual,

— with a level-off altitude 1 000 ft above the go-around initiation altitude.

Textron Aviation comment:

In addition to our broad dissent with inclusion of the performance limiting criteria, more specifically we also consider the guidance for how to treat exceeding the identified parameters to be unclear. Note 2 in **(c) Risk assessment and Mitigation means** states that the numbers should not be considered hard limits, which appears to soften the criteria. But given the final sentence of the section that says exceeding any of the criteria needs to be "duly justified" the overall approach to addressing exceedances is confusing. The section could be made clearer by deleting the final sentence.

~~Alternatively, exceeding any one of the above criteria should be duly justified by the applicant and accepted by the Authority.~~