Study on High Performance Aircraft

Specific contract No SC004 (SAP: 500007063) implementing framework contract No. EASA.2011.FC25

Final Report, Version 2.0

Client: European Aviation Safety Agency

Amsterdam, 14 November 2016

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1 Introduction

This document presents the final report of the Study on High Performance Aircraft, to be performed by the consortium of Ecorys and the National Aerospace Laboratory NLR, with Certiflyer as sub-contractor, under the specific contract No. SC004 (SAP: 500007063) implementing framework contract No. EASA.2011.FC25. It also includes the results of the first and second interim reports.

1.1 Structure of this document

This document is structured as follows:

Section 2 contains background information on the proposed reorganisation of CS-VLA and CS-23, the Air Operations Regulation, and the current definition of High Performance, which have led to the objectives of the Study as specified in section 3:

- To propose a definition of "high performance";
- To identify for which high performance related hazards, risk mitigating measures are missing in the current and under development European regulatory framework for air operations in a broad sense, encompassing airworthiness regulations, flight crew licensing regulations and air operations regulations (gap analysis);
- To define the regulatory options;
- To identify the preferred regulatory options according to the pre-RIA process.

Section 4 contains the methodology used for task 1, and the results of task 1:

- "High performance" is defined and potential incidents due to high performance are identified.

Sections 5, 6, 7 and 8 contain the methodology used for task 2, and the results of task 2:

- In section 5 the mitigating measures and gaps in the EASA regulatory framework for the high performance related incidents identified in section 4 are identified. The results are used to define the regulatory options in section 9.
- In section 6, it is identified which aeroplanes categories do not fall within a Part CAT performance class. The results are used to define the regulatory options in section 9.
  In section 7 the FAA and TCA (Canada) regulatory frameworks are analysed to see if they contain risk mitigating measures (regulations or guidance material) for high performance aircraft which lack in the European regulatory framework. This is used to support the identification high performance related incidents (in section 4) for which risk mitigation measures are missing in the European regulations (in section 5) and the definition of proposed safety recommendations (in section 9).
- In section 8 safety studies on high performance aircraft, as well as accident / incident statistics & reports, are analysed for causal factors (hazards) related to high performance and for safety recommendations. This is used to supports the identification high performance related incidents (in section 4) for which risk mitigation measures are missing in the European regulatory framework (in section 5) and the definition of proposed safety recommendations (in section 9).

Section 9 contains the results from task 3:

- The regulatory options are defined and, in order to assess whether further rulemaking regarding high performance aircraft could be necessary, a Preliminary Regulatory Impact Assessment has been executed.

2 Background information

This section contains background information on the proposed reorganisation of CS-VLA and CS-23, the Air Operations Regulation, and the current definition of High Performance, which have led to the objectives of the Study.

2.1 Proposed reorganisation of CS-VLA and CS-23

For airworthiness regulations, aeroplane types are organised in a number of categories primarily defined by passenger/occupant numbers, weight and propulsion type for the following reasons:

- The more passengers an aeroplane is able to accommodate, the more stringent the regulations (safety level);
- There used to be a clear relationship between weight of an aeroplane with a certain type of propulsion, and its performance and complexity, both driving factors for regulations.

Due to technological developments this second relationship is no longer valid. High performance and complex aeroplanes now exist within aeroplane categories that used to cover lower performance and simpler aeroplanes. This has two effects:

- It has led to more demanding requirements in some categories, which means that for aircraft with lower performance or complexity the requirements can be over-demanding;
- When the regulations for an aircraft category do not contain adequate safety standards for a particular aircraft type, special conditions must be developed. For CS-LSA and CS-VLA aeroplane categories, special conditions are regularly needed. This is also the case with Very Light Jets in CS-23. The development of Special Conditions is time-consuming.

To cope with these effects (among others), the CS-23 and CS-VLA will be replaced by so-called objective requirements that are design-independent and applicable to CS-VLA and CS-23 category aeroplanes. These design-independent requirements will be accompanied by so called Airworthiness Design Standards (ADS) which are the result of merging CS-23 and CS-VLA regulations, and which are Acceptable Means of Compliance to the new design-independent requirements.
The individual ADS that will be applicable follow from the number of occupants (which determines the required safety level) and the technical and operational characteristics such as:

- type of propulsion;
- performance envelope (e.g. stall speed, cruise speed, maximum operating altitude);
- intended type of operation (e.g. IFR/VFR, Day/Night).

This means that for an aircraft type with high performance, it should be possible to select an adequate set of Airworthiness Design Standards.

2.2 Air Operations Regulation

Air Operations Regulation (EU) No.965/2012 prescribes what is required for various commercial and non-commercial types operations.

Among others it contains performance requirements for three performance classes of aircraft within CS-23, i.e.:

- ‘Performance class A aeroplanes’ meaning multi-engined aeroplanes powered by turbo-propeller engines with an MOPSC of more than nine or a maximum take-off mass exceeding 5 700 kg, and all multi-engined turbo-jet powered aeroplanes;
- ‘Performance class B aeroplanes’ meaning aeroplanes powered by propeller engines with an MOPSC of nine or less and a maximum take-off mass of 5 700 kg or less;
- ‘Performance class C aeroplanes’ meaning aeroplanes powered by reciprocating engines with an MOPSC of more than nine or a maximum take-off mass exceeding 5 700 kg.”

As stated above, there used to be a clear relationship between weight of an aeroplane with certain types of propulsion, and its performance and complexity, which is one reason for this division in performance classes. Due to technological developments this classic relationship is no longer valid. This means that there are aircraft types which fall in one of these performance classes with substantially higher performance than other aircraft types within the same class. These so called “high performance aeroplanes might require specific regulations to mitigate the hazards resulting from high performance.

Also there are categories of aircraft within CS-23 that fall outside the three performance classes like:
- single-engined turbo-jet powered aeroplanes (the so called Very Light Jets);
- single-engined turbo-propeller powered aeroplanes with an MOPSC of more than nine; and
- single-engined turbo-propeller powered aeroplanes with a maximum take-off mass exceeding 5 700 kg for which similar performance requirements are missing in Regulation (EU) No.965/2012.

Within these categories of aircraft there may be aircraft types which classify as high performance. These might require specific regulations to mitigate the hazards resulting from high performance.

2.3 Current definition of High Performance

An additional problem is that “high performance” is not defined, although the wording is used in Type Certificate Data Sheets and in Flight Crew Licensing regulations. So first “high performance” must be defined.

3 Objectives of the Study

This section contains the objectives of the Study.

The objectives of the study are:

1. To propose a definition of “high performance”;
2. To identify for which high performance related hazards, risk mitigating measures are missing in the current and under development European regulatory framework for air operations in a broad sense, encompassing airworthiness regulations, flight crew licensing regulations and air operations regulations (gap analysis);
3. To define the regulatory options;
4. To identify the preferred regulatory options according to the pre-RIA process.

It is assumed that the study is limited to the following aircraft categories:

- Light Sports Aeroplanes (CS-LSA);
- Very Light Aeroplanes (CS-VLA);
- Normal, Utility, Aerobatic, Commuter Aeroplanes (CS-23);
- Large Aeroplanes (CS-25).

4 Definition of High Performance and identification of High Performance aircraft

In this section the methodology followed to define high performance and identify high performance aircraft is described.

To get an initial feeling for the problem the performance of jet powered aeroplanes and propeller aeroplanes that are currently considered HPA by EASA, has been compared to non-HPA jet powered aircraft respectively non-HPA propeller aircraft. The findings are described in Appendix 1.

Subsequently the following steps have been performed:
1. Identification of potentially relevant performance parameters;
2. Identification of potential incidents due to high performance;
3. Relating the identified incidents to performance parameters and aeroplane characteristics;
4. Gathering of data of a representative set of aeroplanes;
5. Performance comparison between aeroplane classes and types;
6. Determination of threshold values for high performance.

Each step is described in the sections below.

4.1 Step 1: Identification of potentially relevant performance parameters

First parameters that are potentially relevant for performance have been identified. Relevant performance parameters are those that potentially contribute to an increase in risk of an incident or accident when their value increases.

It is assumed that performance in the context of this study is related to aircraft kinematics, such as acceleration, speed and position. It is assumed that aircraft attitude, angular movements and angular acceleration are out of scope.

The identified performance parameters are listed in table 4.1.

Table 4.1 Performance parameters

Performance parameters	Applicable
Longitudinal acceleration	Yes
Longitudinal deceleration	Yes
Vertical acceleration	Yes
Negative vertical acceleration	Yes
Lateral acceleration	No
Longitudinal speed:	Yes
Climb rate	Yes
Descent rate	Yes
Lateral speed	No
Longitudinal position	No
Lateral position	No
Altitude	Yes

4.2 Step 2: Identification of potential incidents due to high performance

Potential incidents that can occur or are more critical than usual due to the identified high performance parameters, have been identified. Incidents are causal factors of accidents or serious incidents.

Potential incidents considered cover:

- Technical failures;
- External events;
- Environmental conditions;
- Pilot errors: Pilot errors considered are errors caused by limited time to perform tasks in combination with increased complexity of aircraft (higher workload, lower situational awareness).

  Pilot tasks considered are:
  - Aviate including exceeding aircraft or pilot limitations;
  - Navigate & Mission Planning;
  - Communicate;
  - Manage Systems.

    Within these groups of tasks Normal, Abnormal and Emergency procedures are considered.
- Pilot failures (e.g. hypoxia, black-out, red-out, spatial disorientation).

The incidents considered cover all accident categories as defined by ICAO (Ref.2).

The incidents consider all flight phases:

- Taxi;
- Take-off;
- Climb;
- Cruise;
- Descent;
- Approach;
- Landing;
- Go-around.

The assumption is that sea planes are not much different from land planes in terms of incidents that can occur and therefore only land planes have been considered.

The incidents were identified using expert judgement, taking into account:

- All incidents that must be reported under the EU mandatory occurrence reporting scheme (Ref.3);
- All incidents that were identified in the CATS model (Ref.1), which was developed for the Dutch Ministry of Transport and Water-management. The CATS model contains among others the contributing factors of accidents of air transport aircraft and is based on a comprehensive analysis of accidents reports;
- The findings described in Appendix 1.

4.2.1 Identified incidents related to the identified high performance parameters

Below the identified incidents are listed (**in bold font**). Incidents in normal font are not considered critical but are included to show that they have been considered.

Technical failures

- **Explosive decompression at high altitude, and failure to put on oxygen masks quickly and perform an emergency descent => hypoxia;**
- **Supplemental oxygen system failure or cabin pressurisation system failure, and failure to timely detect this and descent => hypoxia;**
- **Engine failure on single engine propeller aeroplanes with high engine power to weight ratio => loss of control.** Although the certification process should ensure controllability in all operational conditions, practice has shown (see for example Ref.4) that on single engine propeller aeroplanes with power plants producing high torque, exceptional pilot skill (fast control inputs in pitch and roll) is required under certain circumstances not recognized during certification. Loss of control may occur e.g. during go-around. There are no explicit requirements to cover this condition apart from general handling and it is an interpretation by the test pilot only;
- **Engine failure on twin engine propeller aeroplanes on the ground or in flight => loss of control;**
- **Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing is exhausted, in case of loss of primary electrical power generating system at high altitude.**

External events

- Bird strike at high take-off or approach speed;
  Bird strike is well covered by CS-23.

Environmental conditions

- Encounter of Clear Air Turbulence at high altitude => injuries, damage
  No extra risk as Clear Air Turbulence also occurs at lower altitudes;
- Encounter thunderstorm at high altitude => in flight break-up, damage, injuries
  No extra risk as thunderstorms also occur at lower altitudes;
- Encounter icing conditions at high altitude => stall
  No extra risk as icing also occurs at lower altitudes.

Pilot errors

Aviate

Taxi:

- Collision with aircraft or obstacles on apron or taxiway due to unexpected high acceleration when applying power Considered not plausible.

Take-off:

- Inappropriate handling during take-off at high acceleration level => veer-off
  Considered not plausible;
- Inappropriate handling during take-off at high speed => veer-off
  Considered not plausible;

- Inappropriate handling after RTO at high speed on short runway, with high deceleration level => veer-off
  In case of absence of anti-skid, reverse, lift dumpers, the risk of wheel skid and runway veer-off is higher. However this applies to all aircraft and not specifically to high performance aeroplanes.

Climb:

- None.

Cruise:

- None.

Descent:

- None.

Approach:

- **Hard landing or long landing due to high approach speed;**
- Unstable approach due to high landing speed. A high landing speed is not a cause of unstable approaches;
- **Hard landing or runway undershoot due to high descent rate in steep approach.**

Landing:

- Aircraft handling during flare inappropriate (wingtip/nacelle strike, long landing, hard landing, off-center landing, LOC veer-off). Considered not plausible;
- Inappropriate handling during landing with high speed => veer-off. Considered not plausible;
- Inappropriate handling after landing at high speed on short runway, with high deceleration level => veer-off. In case of absence of anti-skid, reverse, lift dumpers, the risk of wheel skid and runway veer-off is higher. However this applies to all aircraft and not specifically to high performance aeroplanes.

Go-around:

- None.

Aircraft limitations:

- V_{MO} exceeded => structural overload. This is not specific for HPA;
- **M_{MO} exceeded => high speed buffet;**
- **Maximum operating altitude exceeded. This is not specific for HPA, although there is an additional risk for high performance aircraft (Mach number) of high speed stall in the coffin corner;**
- Max load factor exceeded => damage, in-flight break-up. It is assumed that aerobatic aircraft are well covered by regulations;
- Flap, slat, landing gear, spoiler, speed brake extension limit exceeded during acceleration => structural overload. This is not specific for HPA, and the additional acceleration is not considered critical;
- **Speed brake extended in flight regime for which it is not intended => deceleration => stall.**

Pilot limitations:

- High g load => black out
  Considered well taken care of for aerobatic aircraft;
- High negative g load => red out
  Considered well taken care of for aerobatic aircraft;
- Spatial disorientation due to speed or climb speed
  Considered not plausible.

Navigate &Mission Planning

Navigate:

- **Level bust due to high climb rate;**
- Level bust due to high descent rate in case of a pressurised cabin;
  Not plausible as this is more likely in case of low descent rates and low level of attention. In general level bust are mainly caused by wrong interpretation of charts etc. and not so much by descent rates;
- **Airspace infringement due to high speed;**
- **Loss of separation due to high speed;**
- Route deviation due to high speed. Considered not plausible;
- VFR loss of separation (See and Avoid) due to high closing range. Assumed to be taken care of in ATM domain;
- **CFIT due to high speed and limited time to navigate properly.** Note: no big correlation between CFIT and high speed to be expected;
- Descent below MDA/MDH due to high rate of descent. MDA/MDH implies that a precision or non-precision approach is flown, which have descent angle of 3 degrees with a corresponding descent rate of 500 – 700 ft. min depending on the approach speed. For these descent rates, a descent below MDA/MDH is not considered plausible.

Manage Mission:

- Fuel starvation (poor flight planning) due to not taking large variations of fuel consumption with speed and altitude into account.

Communicate

- **Late communication to other crew members due to high speed;**
- **Late reporting to ATC due to high speed => effect on ATC.**

Manage Systems

- **Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression => hypoxia;**
- **Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system => hypoxia;**
- **Pilot system management (e.g. monitoring of cabin pressurisation) lagging behind events due to high speed or climb rate, especially when aircraft is complex;**
- **Failure to extend landing gear due to high speed (lagging behind events).**

Pilot failures

- **Reduced flight crew performance due to poor ventilation at high altitude.**

4.3 Step 3: Relating the identified incidents to performance parameters and aeroplane characteristics

The identified incidents that were considered relevant are related to the identified performance parameters of table 4.1, and aeroplane characteristics. The results are presented in table 4.2.

Table 4.2 Performance parameters, related aeroplane characteristics and related incidents

Performance parameter	Related aeroplane characteristics	Related incidents
Longitudinal acceleration - ground	minimum take-off distance, V_2	
Longitudinal deceleration - ground	minimum landing distance, V_{REF}	
Longitudinal acceleration – air	indirect via climb rate	
Longitudinal deceleration - air	speed brake present	Speed brake extended in flight regime where this is not permitted => stall
Vertical acceleration	max certified load factor	
Negative vertical acceleration	max certified negative load factor	
Longitudinal speed: Take-off speed	V_2	
Longitudinal speed:	V_{MO}, M_{MO} complexity of aeroplane	Pilot lagging behind events, especially in case of complex aeroplane, complex terrain, complex airspace, e.g. • late communication to other crew members • late reporting to ATC • airspace infringement • loss of separation • improper navigation in the vicinity of terrain (CFIT) • failure to extend landing gear • fuel starvation (poor flight planning due to high variation of fuel consumption with altitude and speed High speed buffet when exceeding M_{MO} When exceeding the maximum operating altitude flight near the coffin corner and the encounter of low and high speed stalls
Longitudinal speed: approach speed	V_{REF} at MLAW	Hard landing => runway excursion of aircraft damage Long landing => runway excursion.
Longitudinal speed: Landing speed	V_{REF} at MLAW	
Climb rate	max climb rate	Level bust Failure to timely detect failure in cabin pressurisation or supplemental oxygen system => hypoxia

Performance parameter	Related aeroplane characteristics	Related incidents
Descent rate	Maximum descent rate cannot be determined due to unknown aerodynamics. An indication is the presence of: pressurised cabin (1500 ft/s), speed brakes, flight spoilers A high descent rate during approach follows from: steep approach capability	Hard landing => runway excursion of aircraft damage Undershoot.
Altitude	service ceiling	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system => hypoxia Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression => hypoxia Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing is exhausted, in case of loss of primary electrical power generating system at high altitude Reduced flight crew performance due to poor ventilation at high altitude
	Engine power on single engine propeller aeroplanes, weight	Loss of control after applying power at low speeds near the stall (e.g. during approach or go-around).
	Significantly more difficult to handle after engine failure than average multi-engine CS-23 aeroplanes	Loss of control after engine failure on the ground or in flight

4.4 Step 4: Gathering of data of a representative set of aeroplanes

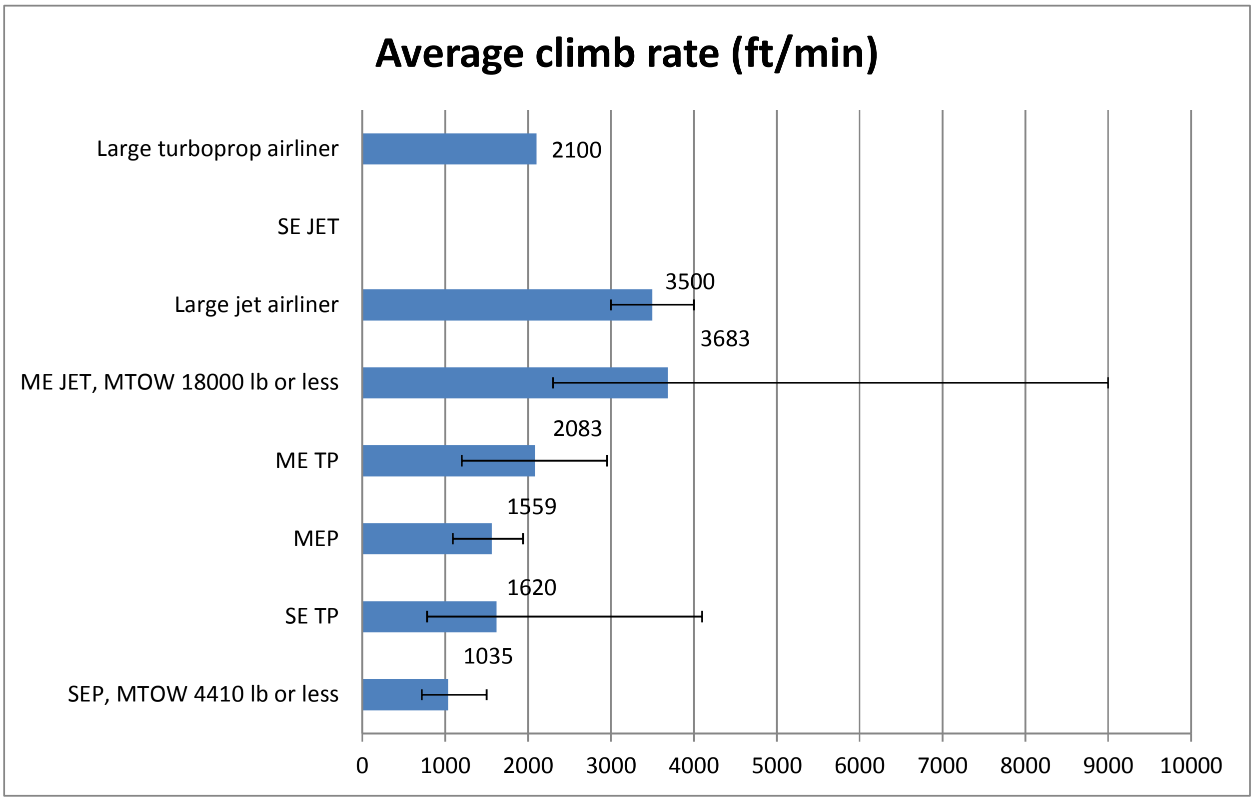
Data (the aeroplane characteristics identified in table 2) of a representative set of aeroplane types covering CS-LSA, CS-LSA, CS-23 and CS-25 has been gathered. All the data were obtained from Aircraft Flight manuals supplemented with information from aircraft brochures and Janes' all the World's Aircraft. These data are presented in Appendix 2 and 3 for propeller respectively jet aeroplanes.

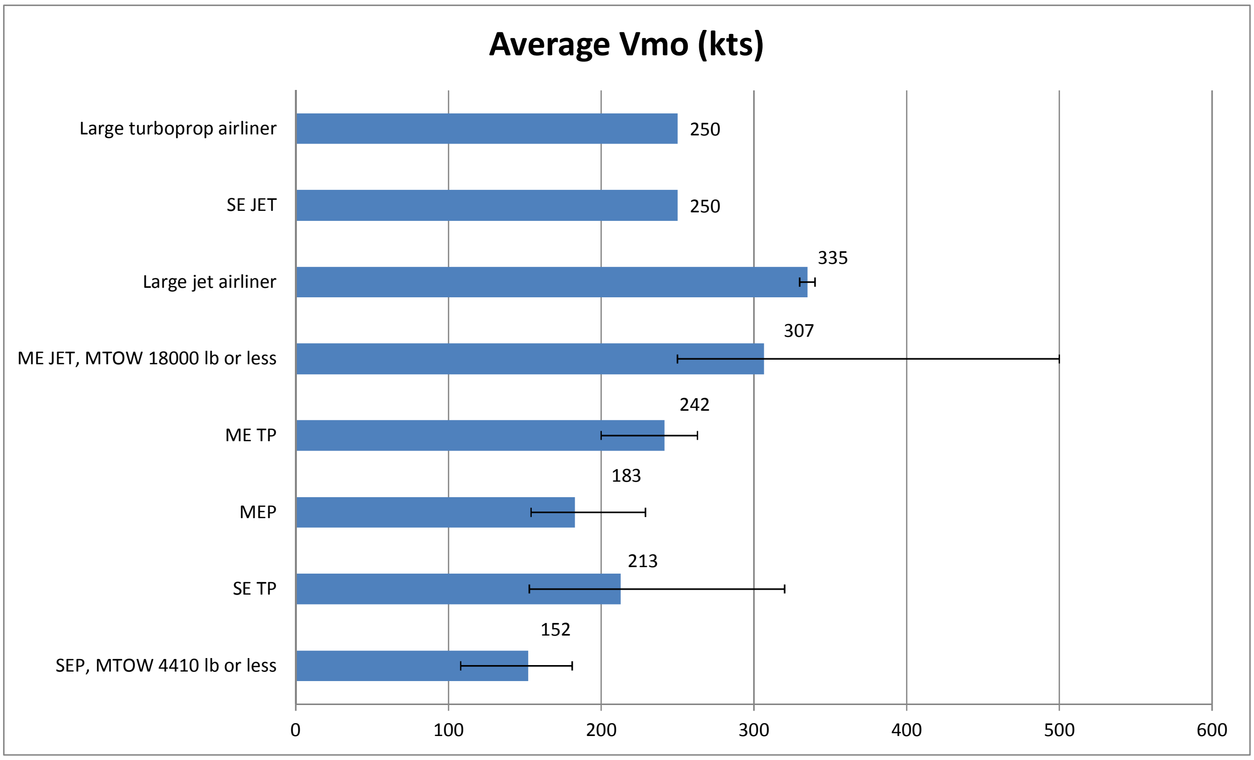
4.5 Step 5: Performance comparison between aeroplane classes and types

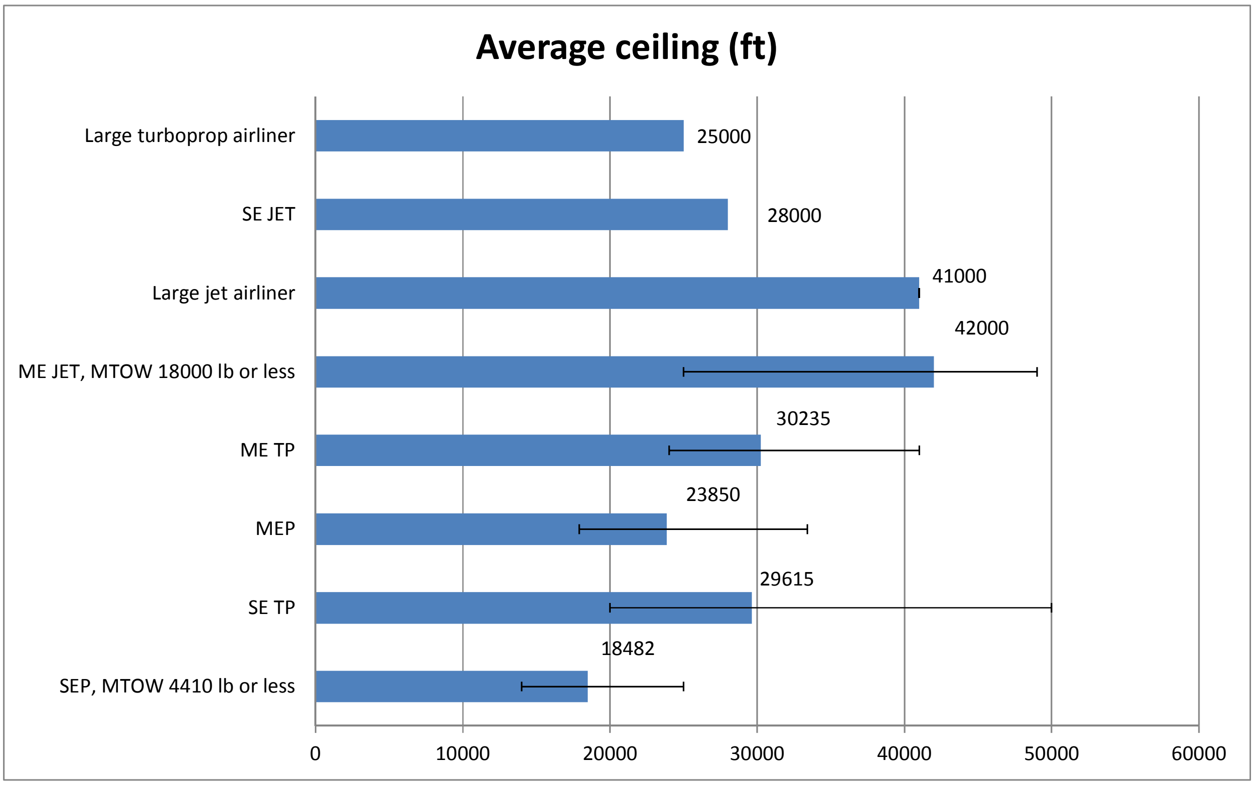
All of the high performance related incidents identified in step 3 are caused by the pilot.
The current Flight Crew Licensing regulations effectively allows pilots, with additional training, to switch from an aeroplane type to any other aeroplane type which may have significant higher

performance. For example from a SEP (with a PPL) to a single engine jet or turboprop (with PPL + type rating).
To assess whether the Flight Crew Licensing regulations are sufficient to cope with these differences in performance (in task 2), first a performance comparison between all types of aeroplanes is required.
Therefore bar charts indicating the performance difference of the various classes of aeroplanes (blue bars), and within each class of aeroplanes (black line segments within blue bars), have been produced.
In order to assess the performance of light twin jets, the category ME JET has been split into below 18,000 lb and above 18,000 lb (as indicated by Large jet airliner). It is assumed that large business jets have similar performance as large jet airliners.

The reason for indicating MTOW 4410 lb or less for the SEP category aeroplane types, is that they are in practice always below 4410 lb, allowing them to be flown with a LAPL licence.




Average Vmo (kts)
Large turboprop airliner
SE JET
Large jet airliner
ME JET, MTOW 18000 lb or less
ME TP
MEP
SE TP
SEP, MTOW 4410 lb or less
250
250
335
307
242
183
213
152
0
100
200
300
400
500
600


Average ceiling (ft)
Large turboprop airliner
SE JET
Large jet airliner
ME JET, MTOW 18000 lb or less
ME TP
MEP
SE TP
SEP, MTOW 4410 lb or less
25000
28000
41000
42000
30235
23850
29615
18482
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30000
40000
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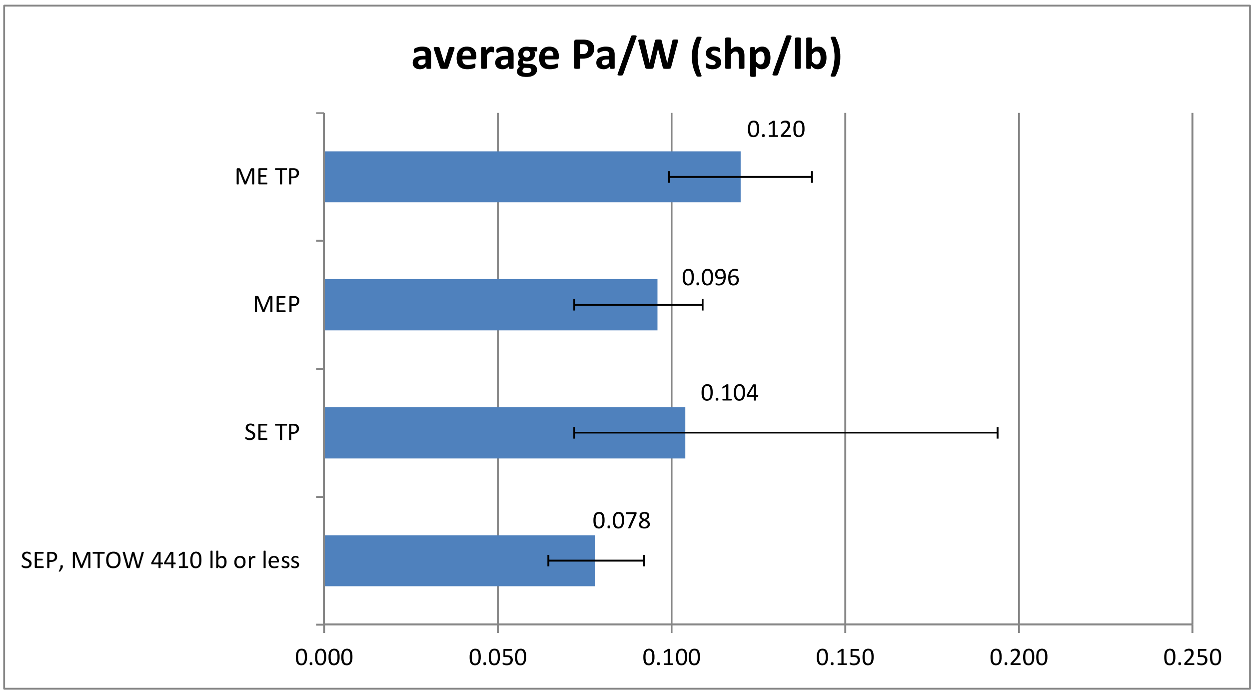
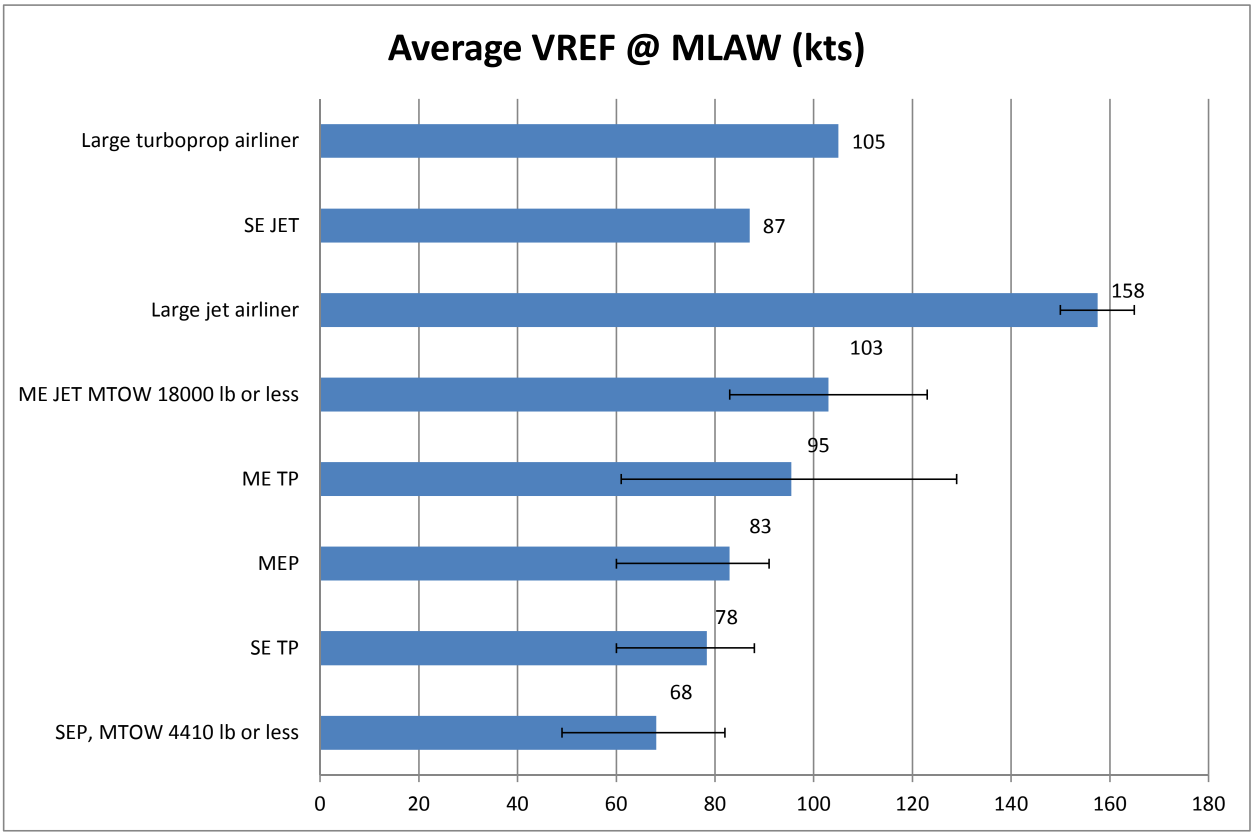




4.6 Step 6: Determination of threshold values for high performance

The threshold values above which an aircraft can be considered high performance in the sense that the risk of incidents becomes substantial for pilots who are not used to this kind of performance, have been determined through test pilot judgement, apart from the 15,000 ft service ceiling threshold which is based on technical data, and the 25,000, 41,000 and 45,000 ft service ceiling thresholds which follow from the gaps in the regulations identified in section 5.

Performance parameter	Threshold for high performance	Justification
Deceleration capability due to presence of speed brake	Presence of speed brake without safety locks to prevent operation in flight regime for which it is not intended	Use of speed brake in flight regime for which it is not intended can result in a stall (e.g. sudden application during approach).
Vmo Mmo	250 kts or Mach 0.65	At this speed a pilot may start lagging behind events, especially in combination with a complex aeroplane, complex terrain or complex airspace. For Mmo possible encounter of high speed buffer or high speed stall when exceeding aircraft limitations.
Approach speed (V_{REF} at MLAW)	100 kts	Vs is 61 kts maximum for single engine aeroplanes. V_{REF} must be greater than 1.3 x Vs, which is approximately 80 kts. It is judged that at speeds above 100 kts, the runway and ground approaches significantly faster than at 80 kts, leaving the pilot with less time to perform tasks with a consequent increased risk of an incident or accident.
Maximum climb rate	2000 ft/min	At this climb rate the risk of a level bust or loss of separation/ACAS alert, especially when aircraft is RVSM equipped increases significantly. There is also an increased risk of not timely detecting a failure in the cabin pressurisation system or supplemental oxygen system.
Descent rate due to steep approach capability	Aircraft certified for steep approach	Steep approaches have a significant increased risk of hard landings or a runway undershoot due to the high descent rate.
Service ceiling	15,000 ft (aspirated threshold)	Until 15,000 no cabin pressurisation of supplemental oxygen is required. Above 15,000 ft there is a risk of hypoxia caused by a combination of explosive decompression, failure of cabin pressurisation or the

Performance parameter	Threshold for high performance	Justification
		supplemental oxygen system and inadequate pilot action (putting on oxygen mask, emergency descent). This risk increases with altitude.
	25,000 ft	Above this altitude it is judged that more than 30 minutes are required to reach an airport after loss of primary electrical power.
	41,000 ft	To adequately cope with explosive decompression, quick donning masks that can be mounted within 5 seconds and a continuous flow oxygen system for passengers should be available, and limits in cabin altitude should be set.
Engine power on single engine propeller aeroplanes, weight	Precise criterion to be developed	Required effort to develop criteria outside scope of study.
Significantly more difficult to handle after engine failure than average multi-engine CS-23 aeroplanes	Precise criterion to be developed	Required effort to develop criteria outside scope of study.

Notes:

- An aeroplane will be defined as High Performance with an indication of the parameters that exceed the above threshold values, to allow the identification of the required mitigating measures / applicable regulations;
- Currently the European regulatory framework does not specify threshold values, but an aeroplane can be classified as HPA in the TC/OEB process;
- Within the Canadian regulatory framework two threshold values are used (see section 7.2.1):
  - A maximum speed (V_{NE}) of 250 KIAS. This is in line with the proposed threshold values for V_{MO} of 250 kts above;
  - A stall speed V_{SO} of 80 KIAS. This can be related to V_{REF} by V_{REF} = 1.3 V_S = 104 KIAS. This is in line with the proposed threshold values for V_{REF} of 100 kts above.
- Within the U.S. regulatory framework one threshold values is used (see section 7.1.1):
  - An aeroplane with an engine of more than 200 horsepower. Using engine power as a threshold is less effective than using the ratio of engine power to weight, if the weight of the applicable aeroplane types can vary significantly. Therefore this definition is not further considered within this study.
- The proposed reorganisation of CS-VLA and CS-23 (see section 2.1) used two threshold values:
  - A maximum speed V_{MO} of 250 kCAS and an M_{MO} of 0.6, both of which are in line with the proposed threshold values for V_{MO} and M_{MO} above.

5 Identification of mitigating measures and gaps in the EASA regulatory framework

In this section the mitigating measures and gaps in the EASA regulatory framework for the high performance related incidents identified in section 4 are identified.

The following steps have been performed:

1. Identification of mitigation measures against identified incidents in the Certification Specifications, flight crew licensing regulations and operations regulations;
2. Identification of allowed combinations of Certification Specification aeroplane category, pilot license and type of operation, for high performance aeroplanes;
3. Identification of gaps in the Certification Specifications, flight crew licensing regulations and operations regulations.

Each step is described in the sections below.

5.1 Step 1: identification of mitigation measures against identified incidents in the Certification Specifications, flight crew licensing regulations and operations regulations

In this step the current and under development European regulatory framework for air operations in a broad sense (encompassing airworthiness regulations, flight crew licensing regulations and air operations regulations) has been analysed to see if it contains risk mitigating measures for the incidents specified in section 1. Risk mitigating measures can be:

- Required aircraft equipment including instruments and cabin equipment;
- Required operating procedures, operational procedures (including the cabin), operating limitations including performance margins;
- Required flight and cabin crew composition, training and experience;
- Required organizational measures (such as duty times, occurrence reporting).

The following parts of the regulations have been analysed:

- CS-VLA, CS-LSA, CS-23 Normal/Utility/Aerobatic, CS-23 Commuter, CS-25
  part NCO, part NCC, part CAT;
  Note: Part SPO (Specialised operations) has not been considered because it is a combination of parts NCO and NCC, both of which were considered;
  Note: Part SPA was not considered because it is about special approvals for special operations.
- part ORO, part ARO;
- part FCL.

The results are shown in the two tables below. Part ARO does not contain mitigating measures and is therefore excluded from the tables.

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
1	Speed brake extended in flight regime where this is not permitted => stall						
2	Lagging behind events due to high speed => late communication to other crew members						
3	Lagging behind events due to high speed => late reporting to ATC						
4a	Lagging behind events due to high speed => airspace infringement						
4b	Lagging behind events due to high speed => loss of separation						
5	Lagging behind events due to high speed => improper navigation in the vicinity of terrain (CFIT)			AMC3 ORO.MLR.100 Operations manual — general CONTENTS — COMMERCIAL AIR TRANSPORT OPERATIONS GPWS procedures	**GM1 NCO.IDE.A.130 Terrain awareness warning system (TAWS):** TAWS Class A and B standards mentioned	**GM1 NCC.IDE.A.135 Terrain awareness warning system (TAWS):** TAWS Class A and B standards mentioned **GM1 NCC.OP.215 Ground proximity**	**CAT.IDE.A.150 Terrain awareness warning System (TAWS)** (a) Turbine-powered aeroplanes having an MCTOM of more than 5 700 kg or an MPSC of more than nine shall be equipped with a

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
						detection: TAWS flight crew training program	TAWS that meets the requirements for Class A equipment as specified in the applicable European technical standards order (ETSO) issued by the Agency. (b) Reciprocating-engine-powered aeroplanes with an MCTOM of more than 5 700 kg or an MPSC of more than nine shall be equipped with a TAWS that meets the requirement for Class B equipment as specified in the applicable ETSO issued by the Agency. **GM1 CAT.IDE.A.150 Terrain awareness warning system (TAWS):** TAWS Class A and B standards mentioned. **GM1 CAT.OP.MPA.290**

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
							Ground proximity detection: TAWS flight crew training program.
6	Lagging behind events due to high speed => failure to extend landing gear	CS 23.729 Landing gear extension and retraction system does require a landing gear not extended warning based on wings flaps maximum extended and throttles closed.	CS 25.729 Retracting mechanism requires a warning when a landing is attempted which implies coverage of all approaches.				
7	Fuel starvation (poor flight planning) due to large variation of fuel consumption with altitude and speed						
8	Exceeding M_{MO} and high speed buffet => high speed stall	Good mitigation, although required absence of exceptional piloting strength or skill as in CS-25 is lacking. **CS 23.1545 Airspeed indicator** maximum allowable airspeed indication showing the variation of VMO/MMO with altitude or compressibility limitations (as appropriate), or a radial red line marking for VMO/MMO must be made at lowest value of VMO/MMO established for any altitude up to the maximum	Good mitigation **CS 25.1583 Operating limitations** The airspeed limitations must be easily read and understood by the flight crew. **CS 25.1583 Operating limitations** If an airspeed limitation is based upon compressibility effects, a statement to this effect and information as to any symptoms, the probable				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
		operating altitude for the aeroplane. **CS 23.1583 Operating limitations** If an airspeed limitation is based upon compressibility effects, a statement to this effect and information as to any symptoms, the probable behaviour of the aeroplane and the recommended recovery procedures. **CS 23.253 High speed characteristics** (b) Allowing for pilot reaction time after occurrence of effective inherent or artificial speed warning specified in CS 23.1303, it must be shown that the aeroplane can be recovered to a normal attitude and its speed reduced to VMO/MMO without – (1) Exceeding VD/MD, the maximum speed shown under CS 23.251, or the structural limitations; or (2) Buffeting that would impair the pilot's ability to read the	behaviour of the aeroplane, and the recommended recovery procedures. **CS 25.253 High-speed characteristics** (2) Allowing for pilot reaction time after effective inherent or artificial speed warning occurs, it must be shown that the aeroplane can be recovered to a normal attitude and its speed reduced to VMO/MMO, without – (i) Exceptional piloting strength or skill; (ii) Exceeding VD/MD, VDF/MDF, or the structural limitations; and (iii) Buffeting that would impair the pilot's ability to read the instruments or control the aeroplane for recovery. (3) With the aeroplane trimmed at any speed up to VMO/MMO, there must be no reversal of the response to control input about any axis at any speed up to VDF/MDF. Any tendency to pitch, roll, or yaw must be mild and readily				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
		instruments or to control the aeroplane for recovery. (c) There may be no control reversal about any axis at any speed up to the maximum speed shown under CS 23.251. Any reversal of elevator control force or tendency of the aeroplane to pitch, roll, or yaw must be mild and readily controllable, using normal piloting techniques.	controllable, using normal piloting techniques. When the aeroplane is trimmed at VMO/MMO, the slope of the elevator control force versus speed curve need not be stable at speeds greater than VFC/MFC, but there must be a push force at all speeds up to VDF/MDF and there must be no sudden or excessive reduction of elevator control force as VDF/MDF is reached.				
9	Exceeding maximum operating altitude and flight near the coffin corner => low speed and/or high speed stall	Mitigation similar to CS-25 without the requirements to be able to manoeuver at altitude) **CS 23.1527 Maximum operating altitude** (a) The maximum altitude up to which operation is allowed, as limited by flight, structural, powerplant, functional, or equipment characteristics, must be established. **CS 23.251 Vibration and buffeting** There must be no vibration or buffeting severe enough to result in structural damage and	A clear indication of the maximum operating altitude is missing. **CS 25.1527 Ambient air temperature and operating altitude** The extremes of the ambient air temperature and operating altitude for which operation is allowed, as limited by flight, structural, powerplant, functional, or equipment characteristics, must be established. **CS 25.251 Vibration and buffeting**				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
		each part of the aeroplane must be free from excessive vibration, under any appropriate speed and power conditions up to at least the minimum value of VD allowed in CS 23.335. In addition there must be no buffeting in any normal flight condition severe enough to interfere with the satisfactory control of the aeroplane or cause excessive fatigue to the flight crew. Stall warning buffeting within these limits is allowable.	(e) For an aeroplane with MD greater than 0·6 or with a maximum operating altitude greater than 7620 m (25,000 ft), the positive manoeuvring load factors at which the onset of perceptible buffeting occurs must be determined with the aeroplane in the cruise configuration for the ranges of airspeed or Mach number, weight, and altitude for which the aeroplane is to be certificated. The envelopes of load factor, speed, altitude, and weight must provide a sufficient range of speeds and load factors for normal operations. Probable inadvertent excursions beyond the boundaries of the buffet onset envelopes may not result in unsafe conditions. (See AMC 25.251(e).)				
10	Hard landing due to high approach speed						
11	Long landing due to high approach speed						
12	Level bust due to high climb rate	No mitigation in CS-23	Good mitigation **CS-25 Book 2 - AMC,**	**AMC3 ORO.MLR.100 Operations manual — general**		**GM1 NCC.OP.220 Airborne collision avoidance system**	**CAT.IDE.A.155 Airborne Collision Avoidance System**

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
			Appendix 1, Primary Flight Information, 2.1 Airspeed and Altitude: enough scale length and markings to reinforce the flight crew's sense of altitude and to allow sufficient look –ahead room to adequately predict and accomplish level-off.	CONTENTS — COMMERCIAL AIR TRANSPORT OPERATIONS ACAS procedures		**(ACAS):** ACAS flight crew training program	**(ACAS)** TURBINE-POWERED AEROPLANES WITH A MAXIMUM CERTIFIED TAKE-OFF MASS OF MORE THAN 5 700 KG OR A MAXIMUM PASSENGER SEATING CONFIGURATION OF MORE THAN 19 SHALL BE EQUIPPED WITH ACAS II.CAT.IDE.A.160 AIRBORNE WEATHER DETECTING EQUIPMENT The following shall be equipped with airborne weather detecting equipment when operated at night or in instrument meteorological conditions (IMC) in areas where thunderstorms or other potentially hazardous

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
							weather conditions, regarded as detectable with airborne weather detecting equipment, may be expected to exist along the route: (a) pressurised aeroplanes, (b) non-pressurised aeroplanes with an MCTOM of more than 5 700 kg; and (c) non-pressurised aeroplanes with an MPSC of more than nine. **GM1 CAT.OP.MPA.295 Use of airborne collision avoidance system (ACAS):** ACAS flight crew training program.
13	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate =>	Inadequate mitigation: • CS 23.365 Pressurised compartment loads less stringent than CS 25.365 Pressurised compartment loads;	Good mitigation **CS 25.365 Pressurised compartment loads** **CS 25.841 Pressurised**				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
	hypoxia	• CS 23.841 does not require that loss of pressure warning will be given without delay, as in CS 25.841; • CS 23.841 does not require that aural or visual signal (in addition to cabin altitude indication means) is given, as in CS 25.841. **CS 23.365 Pressurised compartment loads** **CS 23.841 Pressurised cabins** (6) Warning indication at the pilot station to indicate when the safe or pre-set pressure differential is exceeded and when a cabin pressure altitude of 3048m (10 000 ft) is exceeded.	**cabins** (8) The pressure sensors necessary to meet the requirements of sub-paragraphs (b)(5) and (b)(6) of this paragraph and CS 25.1447 (c), must be located and the sensing system designed so that, in the event of loss of cabin pressure in any passenger or crew compartment (including upper and lower lobe galleys), the warning and automatic presentation devices, required by those provisions, will be actuated without any delay that would significantly increase the hazards resulting from decompression. **CS 25.841 Pressurised cabins** (6) Warning indication at the pilot or flight engineer station to indicate when the safe or pre-set pressure differential and cabin pressure altitude limits are exceeded. Appropriate warning markings on the cabin pressure				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
			differential indicator meet the warning requirement for pressure differential limits and an aural or visual signal (in addition to cabin altitude indicating means) meets the warning requirement for cabin pressure altitude limits if it warns the flight crew when the cabin pressure altitude exceeds 3048 m (10 000 ft).				
14	Hard landing due to steep approach	No mitigation in CS-23	Good mitigation **SAL) 25.3 Steep Approach Landing Distance** (Applicable only if a reduced landing distance is sought, or if the landing procedure (speed, configuration, etc.) differs significantly from normal operation, or if the screen height is greater than 50 ft.) (5) The landings may not require exceptional piloting skill or alertness.				
15	Undershoot due to steep approach	No mitigation in CS-23	Good mitigation **SAL) 25.3 Steep Approach Landing Distance** (Applicable only if a reduced landing distance is sought, or				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
			if the landing procedure (speed, configuration, etc.) differs significantly from normal operation, or if the screen height is greater than 50 ft.) (5) The landings may not require exceptional piloting skill or alertness.				
16	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system at high altitude => hypoxia	Inadequate mitigation (see 3 rows here above)	Good mitigation (see 3 rows here above)				
17	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia				**AMC1 NCO.IDE.A.150 Supplemental oxygen — pressurised aeroplanes** DETERMINATION OF OXYGEN (b) The amount of oxygen should be determined on the basis of cabin pressure altitude, flight duration, and on the assumption that a	**AMC1 NCC.IDE.A.195 Supplemental oxygen — pressurised aeroplanes** DETERMINATION OF OXYGEN(b) The amount of oxygen should be determined on the basis of cabin pressure altitude and flight duration, and on the	**AMC1 CAT.IDE.A.235 Supplemental oxygen — pressurised aeroplanes** DETERMINATION OF OXYGEN (b) The amount of supplemental oxygen should be determined on the basis of cabin pressure altitude, flight duration and on the assumption that a cabin pressurisation

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
					cabin pressurisation failure will occur at the pressure altitude or point of flight that is most critical from the standpoint of oxygen need.	assumption that a cabin pressurisation failure will occur at the pressure altitude or point of flight that is most critical from the standpoint of oxygen need.	failure will occur at the pressure altitude or point of flight that is most critical from the standpoint of oxygen need.
18	Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing is exhausted, in case of loss of primary electrical power generating system at high altitude (tbd ft)	**CS 23.1353 Storage battery design and Installation** (h) In the event of a complete loss of the primary electrical power generating system, the battery must be capable of providing 30 minutes of electrical power to those loads that are essential to continued safe flight and landing. The 30-minute time period includes the time needed for the pilot(s) to recognise the loss of generated power and to take appropriate load shedding action.	Inadequate mitigation • Between 25,000 ft and 41,000 ft the requirement from CS-25.1447 that oxygen dispensing units must be within easy reach and can be placed into position within 5 seconds is missing; • **CS 23.1441 Oxygen equipment and supply** does not include oxygen flow rate requirements for above 40000 ft as in CS-25.1441. **CS 23.1447 Equipment standards for oxygen dispensing units** If oxygen dispensing units are installed, the following apply: (a) There must be an individual dispensing unit for	Good mitigation **CS 25.1447 Equipment standards for oxygen dispensing units** If oxygen-dispensing units are installed, the following apply: (a) There must be an individual dispensing unit for each occupant for whom supplemental oxygen is to be supplied. Units must be designed to cover the nose and mouth and must be equipped with a suitable means to retain the unit in position on the face. Flight crew masks for supplemental oxygen			

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
			each occupant for whom supplemental oxygen is to be supplied. Each dispensing unit must – (2) Be capable of being readily placed into position on the face of the user. (d) For a pressurised aeroplane designed to operate at flight altitudes above 7620m (25 000 ft) (MSL), the dispensing units must meet the following: (1) The dispensing units for passengers must be connected to an oxygen supply terminal and be immediately available to each occupant, wherever seated. (2) The dispensing units for crewmembers must be automatically presented to each crewmember before the cabin pressure altitude exceeds 4572m (15 000 ft), or the units must be of the quick-donning type, connected to an oxygen supply terminal that is immediately available to crewmembers at their station.	must have provisions for the use of communication equipment. (b) If certification for operation up to and including 7620 m (25 000 ft) is requested, an oxygen supply terminal and unit of oxygen dispensing equipment for the immediate use of oxygen by each crew member must be within easy reach of that crew member. For any other occupants the supply terminals and dispensing equipment must be located to allow use of oxygen as required by the operating rules. (c) If certification for operation above 7620 m (25 000 ft) is requested, there must be oxygen dispensing equipment meeting the following requirements (See AMC 25.1447(c)):			

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
			(e) If certification for operation above 9144m (30 000 ft) is requested, the dispensing units for passengers must be automatically presented to each occupant before the cabin pressure altitude exceeds 4572m (15 000 ft). **FAR §23.1447 Equipment standards for oxygen dispensing units.** (g) If the airplane is to be certified for operation above 41,000 feet, a quick-donning oxygen mask system, with a pressure demand, mask mounted regulator must be provided for the flight crew. This dispensing unit must be immediately available to the flight crew when seated at their station and installed so that it: (1) Can be placed on the face from its ready position, properly secured, sealed, and supplying oxygen upon demand, with one hand, within five seconds and without disturbing eyeglasses or	(1) There must be an oxygen dispensing unit connected to oxygen supply terminals immediately available to each occupant, wherever seated. If certification for operation above 9144 m (30 000 ft) is requested, the dispensing units providing the required oxygen flow must be automatically presented to the occupants before the cabin pressure altitude exceeds 4572 m (15 000 ft) and the crew must be provided with a manual means to make the dispensing units immediately available in the event of failure of the automatic system. (2) Each flight-crew member on flight deck duty must be provided with demand			

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
			causing delay in proceeding with emergency duties	equipment. In addition, each flight-crew member must be provided with a quick donning type of oxygen dispensing unit, connected to an oxygen supply terminal, that is immediately available to him when seated at his station, and this is designed and installed so that it (see AMC 25.1447 (c)(2)) (i) Can be placed on the face from its ready position, properly secured, sealed, and supplying oxygen upon demand, with one hand within 5 seconds and without disturbing eyeglasses or causing delay in proceeding with emergency duties **CS 25.1441 Oxygen equipment and supply** (d) The oxygen flow			

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
				rate and the oxygen equipment for aeroplanes for which certification for operation above 12192 m (40 000 ft) is requested must be approved. (See AMC 25.1441(d).)			
19	Reduced flight crew performance due to poor ventilation at high altitude	**CS 23.831 Ventilation** (a) Each passenger and crew compartment must be suitably ventilated. Carbon monoxide concentration may not exceed one part in 20 000 parts of air. (b) For pressurised aeroplanes, the ventilating air in the flight crew and passenger compartments must be free of harmful or hazardous concentrations of gases and vapours in normal operations and in the event of reasonably probable failures or malfunctioning of the ventilating, heating, pressurisation, or other systems and equipment.	**CS 25.831 Ventilation** (a) Each passenger and crew compartment must be ventilated and each crew compartment must have enough fresh air (but not less than 0.28 m3/min. (10 cubic ft per minute) per crewmember) to enable crew members to perform their duties without undue discomfort or fatigue.				
20	Loss of control after applying power at low speeds near the stall (e.g. during	Adequate mitigation **CS 23.143 General** (a) The aeroplane must be	Not applicable. Single engine propeller aeroplanes do not exist in CS-				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
	approach or go-around) on single engine propeller aeroplanes with high power to weight ratio	safely controllable and manoeuvrable during all flight phases including – (1) Take-off; (2) Climb; (3) Level flight; (4) Descent; (5) Go-around; and (6) Landing (power on and power off) with the wing flaps extended and retracted. (b) It must be possible to make a smooth transition from one flight condition to another (including turns and slips) without danger of exceeding the limit load factor, under any probable operating condition, (including, for multi-engined aeroplanes, those conditions normally encountered in the sudden failure of any engine). **CS 23.145 Longitudinal control** (b) It must be possible to carry out the following manoeuvres without requiring the application of single handed control forces exceeding those specified in CS 23.143 (c), unless otherwise	25				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
		stated. The trimming controls must not be adjusted during the manoeuvres: (2) With landing gear and flaps extended, power off and the aeroplane as nearly as possible in trim at 1·3 VSO, quickly apply take-off power and retract the flaps as rapidly as possible to the recommended go-around setting and allow the airspeed to transition from 1·3 VSO to 1·3 VS1. Retract the gear when a positive rate of climb is established. However CS 23.143 is subjective to the judgement of a test pilot though. Specific flight handling criteria are not provided. This has led to type rating inconsistencies. For example the Socata TBM700, which is quite unforgiving, does not require a type rating, whereas the Pilatus PC-12 which is easier to fly, does require a type rating.					
21	Loss of control after engine failure on the ground or in flight on	The difference between CS-23 and CS-25 is small: CS-23 requires the minimum V1	Good mitigation Adequate margins are				

No.	Identified incident	CS-23 mitigation	CS-25 mitigation	part ORO mitigation	part NCO mitigation	part NCC mitigation	Part CAT mitigation
	multi-engine aeroplane	to be either 1.05 Vmca or Vmcg. CS-25 requires the minimum V1 to be Vmcg. In practice there is only a difference if 1.05 Vmca is smaller than Vmch which will is not very likely. CS-23 does not require a Vr. This does not seem to lead to incidents in practice. CS-23 does not require the ability to perform a turn that is free of stall warnings @ V2. It is assessed that this is sufficiently covered by the minimum requirements imposed on V2 and Vmc. Summarising: CS-23 adequately covers this incident.	required by CS-25.				

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
1. Speed brake extended in flight regime where this is not permitted => stall	Mitigation if type identified as HPA // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - MCC training and/or type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation due to training and experience in unusual attitudes		Mitigation due to training and experience with testing outside the normal envelope
2. Lagging behind events due to high speed => late	Mitigation if MPL or MCC training FCL	Mitigation if MPL or MCC training		Mitigation due to training on the use of instrumentation	Mitigation if MPL or MCC training	Mitigation by MCC training or MPL / FCL	Mitigation by MCC training or MPL / FCL	Mitigation by MCC training or MPL / FCL			Mitigation due to training and experience

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
communication to other crew members	720A	FCL 720A			FCL 720A	415	415	415			with team processes
3. Lagging behind events due to high speed => late reporting to ATC	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 - 720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - MCC training and/or type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9		Mitigation due to training of flying under ATC control	Mitigation by type rating training / FCL 725	Mitigation by CPL training / FCL 310	Mitigation by CPL training / FCL 310	Mitigation by CPL training / FCL 310			Mitigation due to training and experience with unusual use of airspace

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
4a. Lagging behind events due to high speed => airspace infringement	Standard pilot knowledge	Standard pilot knowledge			Standard pilot knowledge	Standard pilot knowledge	Standard pilot knowledge	Standard pilot knowledge			
4b. Lagging behind events due to high speed => loss of separation	Standard pilot knowledge	Standard pilot knowledge			Standard pilot knowledge	Standard pilot knowledge	Standard pilot knowledge	Standard pilot knowledge			
5. Lagging behind events due to high speed => improper navigation in the vicinity of terrain (CFIT)	No mitigation. TAWS not required	No mitigation. TAWS not required		Mitigation due to training of flying under ATC control and usage of maps		Mitigation by TAWS requirement when commercial (part CAT)	Mitigation by TAWS requirement when commercial (part CAT)	Mitigation by TAWS requirement when commercial (part CAT)		Mitigation due to training and experience in high terrain	Mitigation due to training and experience with operations close to terrain
6. Lagging behind events due to high speed => failure to extend landing gear											

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
7. Fuel starvation (poor flight planning) due to large variation of fuel consumption with altitude and speed	Standard pilot knowledge	Standard pilot knowledge			Standard pilot knowledge	Standard pilot knowledge	Standard pilot knowledge	Standard pilot knowledge			
8. Exceeding M_{MO} and high speed buffet => high speed stall	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 - 720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - MCC training and/or type rating required // Regulation 1178-			Mitigation by type rating training / FCL 725	Mitigation by CPL training and/or Type rating / FCL 320 / FCL 305 / FCL 725	Mitigation by CPL training and/or Type rating / FCL 320 / FCL 305	Mitigation by CPL training and/or Type rating / FCL 320 / FCL 305	Mitigation due to training and experience in unusual attitudes		Mitigation due to training and experience with testing outside the normal envelope

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
		2011 FCL 710-720-725 - Appendix 8 and 9									
9. Exceeding maximum operating altitude and flight near the coffin corner => low speed and/or high speed stall	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 - 720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - MCC training and/or type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Mitigation by type rating training / FCL 725	Mitigation by CPL training and/or Type rating / FCL 320 / FCL 305 / FCL 725	Mitigation by CPL training and/or Type rating / FCL 320 / FCL 305	Mitigation by CPL training and/or Type rating / FCL 320 / FCL 305	Mitigation due to training and experience in unusual attitudes		Mitigation due to training and experience with testing outside the normal envelope

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
10. Hard landing due to high approach speed	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 - 720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725			Mitigation due to training and experience with performance testing
11. Long landing due to high approach speed	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 -	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot			Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725			Mitigation due to training and experience with performance testing

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
	720-725 - Appendix 8 and 9	aircraft - type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9									
12. Level bust due to high climb rate	No mitigation. ACAS not required	No mitigation. ACAS not required		Mitigation due to training of procedural flying		Mitigation by required ACAS when Commercial (part CAT)	Mitigation by required ACAS when Commercial (part CAT)	Mitigation by required ACAS when Commercial (part CAT)			Mitigation due to training and experience with HPA
13. Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia	No Mitigation. Hypoxia training not required	No Mitigation. Hypoxia training not required			Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725		Mitigation due to training and experience at high altitudes	Mitigation due to training and experience with testing outside the normal envelope and Hypoxia training

Licence / Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
14. Hard landing due to steep approach	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 - 720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725			Mitigation due to training and experience with performance testing
15. Undershoot due to steep approach	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 -	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot			Mitigation by type rating training / FCL 725	Mitigation by CPL training / FCL 320	Mitigation by CPL training / FCL 320	Mitigation by CPL training / FCL 320			Mitigation due to training and experience with performance testing

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
	720-725 - Appendix 8 and 9	aircraft - type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9									
16. Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system at high altitude => hypoxia	No Mitigation. Hypoxia training not required	No Mitigation. Hypoxia training not required				Mitigation by CPL training / FCL 310	Mitigation by CPL training / FCL 310	Mitigation by CPL training / FCL 310		Mitigation due to training and experience at high altitudes	Mitigation due to training and experience with testing outside the normal envelope and Hypoxia training
17. Failure to timely put on oxygen mask and/or perform emergency descent after	No Mitigation. Procedure training not required	No Mitigation. Procedure training not required				Mitigation by CPL training / FCL 310	Mitigation by CPL training / FCL 310	Mitigation by CPL training / FCL 310			Mitigation due to training and experience with testing outside the

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
rapid decompression at high altitude => hypoxia											normal envelope and Hypoxia training
18. Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing is exhausted, in case of loss of primary electrical power generating system at high altitude (tbd ft)											
19. Reduced flight crew performance											

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
due to poor ventilation at high altitude											
20. Loss of control after applying power at low speeds near the stall (e.g. during approach or go-around) on single engine propeller aeroplanes with high power to weight ratio	Mitigation if type identified as High performance // Regulation 1178-2013 FCL 710 - 720-725 - Appendix 8 and 9	Mitigation if type identified as single pilot HPA or multi engine. If multi pilot aircraft - type rating required // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9		Mitigation due to training of manoeuvres under instrument conditions	Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation		Mitigation due to training and experience with performance testing

Licence Related incidents	LAPL	PPL without type rating	Multi engine piston class rating FCL 725	PPL with instrument rating FCL 600-825	PPL with type rating	CPL	MPL	ATPL	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
21. Loss of control after engine failure on the ground or in flight on multi-engine aeroplane	N.A.	N.A.	Mitigation by MEP required training **FCL.725.A**		Mitigation by type rating training / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725	Mitigation by CPL and/or type rating training / FCL 310 / FCL 305 / FCL 725			Mitigation due to training and experience with testing outside the normal envelope

5.2 Step 2: Identification of allowed combinations of Certification Specifications aeroplane category, pilot license and type of operation, for high performance aeroplanes

5.2.1 *Step 2a: Identification of allowed combinations of pilot license, aeroplane type and type of operation*

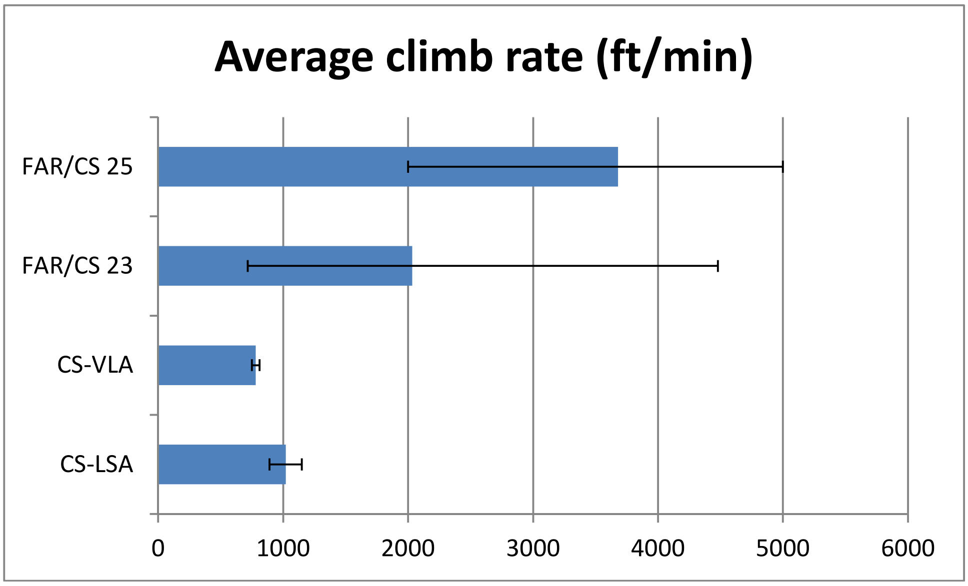
First it has been assessed what combinations of pilot license, aeroplane type and type of operation are allowed, based on part FCL.

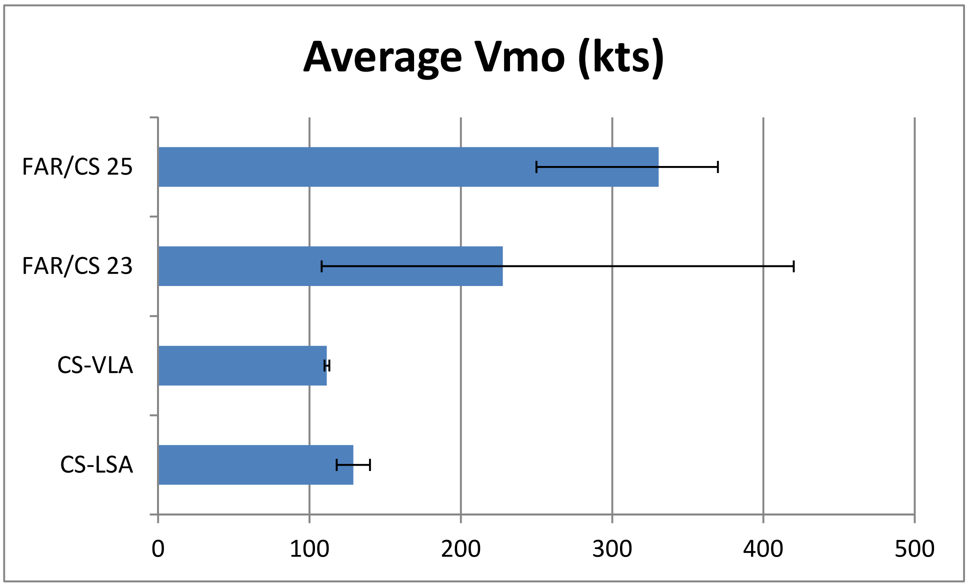
Licence & rating	LAPL	PPL without type rating	PPL without type rating, with MEP class rating FCL 725	PPL with type rating	CPL	MPL	ATPL	Instrument rating FCL 600-825	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
Privileges					LAPL+PPL privileges	LAPL+PPL+ CPL privileges	LAPL+PPL+ CPL privileges				
Aircraft weight	Less than 2000 kg	Less than 5700 kg	Less than 5700 kg	More than 5700 kg	All weights	All weights	All weights				
Number of pax	Less than 2 pax/2 total	Less than 4 pax/4 total	Less than 4 pax/4 total	Less than 4 pax/4 total	All pax	All pax	All pax				
Type and number of engine(s)	Single Piston	Single Piston	Multi Piston	Any	Any	Any	Any				
CS category	CS-LSA CS-VLA CS-23 Normal	CS-LSA CS-VLA CS-23 Normal	CS-LSA CS-VLA CS-23 Normal CS-23 Commuter	CS-LSA CS-VLA CS-23 Normal CS-23 Commuter CS-25	CS-LSA CS-VLA CS-23 Normal CS-23 Commuter CS-25	CS-LSA CS-VLA CS-23 Normal CS-23 Commuter CS-25	CS-LSA CS-VLA CS-23 Normal CS-23 Commuter CS-25				
Type of operation	Non-Commercial	Non-Commercial	Non - Commercial	Non-Commercial	PIC Non-Commercial COP	Commercial	Commercial				

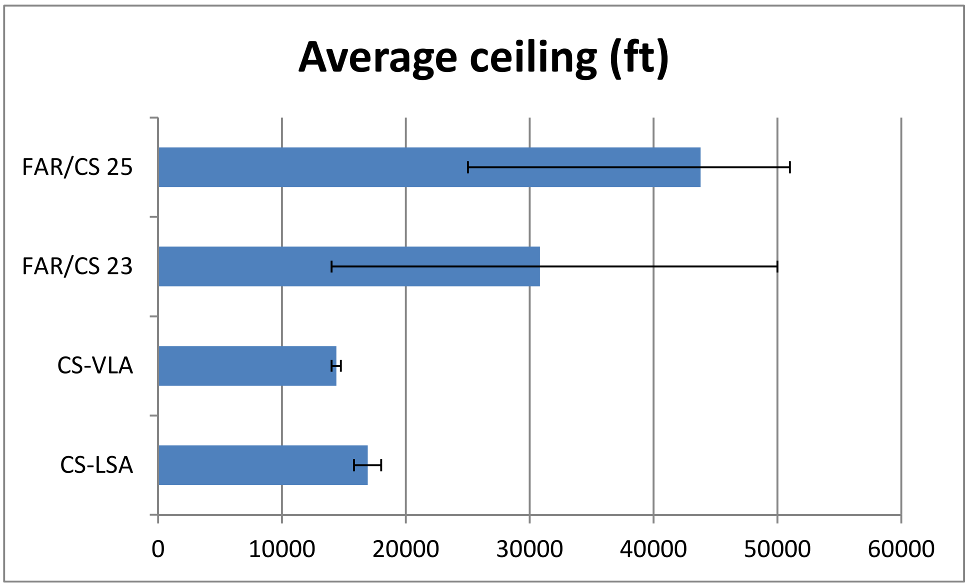
Licence & rating	LAPL	PPL without type rating	PPL without type rating, with MEP class rating FCL 725	PPL with type rating	CPL	MPL	ATPL	Instrument rating FCL 600-825	Aerobatic rating FCL 800	Mountain rating FCL 815	Flight test rating FCL 820
					Commercial						
PIC or COP	PIC Non-Commercial	PIC Non-Commercial	PIC Non-Commercial	PIC Non-Commercial	PIC Non-Commercial COP Commercial	PIC multi crew a/c	PIC Commercial COP Commercial				
Number of pilot(s)	Single	Single	Single	Single/Multi	Single/Multi	Multi	Single/Multi				
Training / Experience							CPL + experience MPL or MCC training				

5.2.2 *Step 2b: Identification of high performance aeroplanes per Certification Specification aeroplane category*

Subsequently bar charts per CS category (CS-LSA, CS-VLA, CS-23, CS-25) have been produced (see below) to indicate whether any of the high performance thresholds is exceeded by aircraft within that category:







Conclusions:

CS-25	All aeroplanes within this category are HPA.
CS-23	HPA and non-HPA aeroplanes within this category
CS-VLA	There are no HPA aeroplanes within this category.
CA-LSA	There are HPA with regard to maximum operating altitude. It is judged however that this altitude will not be reached in practice due to the low slow climb rate.

5.2.3 Step 2c: Identification of allowed combinations of Certification Specifications aeroplane category, pilot license and type of operation, for high performance aeroplanes

The tables from step 2a and 2b have been combined into the following table that shows the allowed combinations of pilot license, CS category aeroplane and type of operation, for high performance aeroplanes. CS-LSA and CS-VLA category aeroplanes have been omitted as there are no high performance aeroplanes within these CS categories.
This table is used as input for section 9.6.2 where it will be identified in what areas of the allowed combinations gaps exist, using the results from step 3.

Licence / rating: Privileges:	LAPL	PPL without type rating	PPL without type rating, with MEP class rating	PPL with type rating	CPL	MPL	ATPL
Aircraft weight	Less than 2000 kg	Less than 5700 kg	Less than 5700 kg	More than 5700 kg	All weights	All Weights	All Weights
Number of pax	Less than 2 pax/4 total	Less than 4 pax/4 total	Less than 4 pax/4 total	Less than 4 pax/4 total	All Pax	All Pax	All Pax
Type and number of engine(s)	Single Piston	Single Piston	Multi Piston	Any	Any	Any	Any
CS category	CS-23 Normal	CS-23 Normal	CS-23 Normal CS-23 Commuter	CS-23 Normal CS-23 Commuter CS-25	CS-23 Normal CS-23 Commuter CS-25	CS-23 Normal CS-23 Commuter CS-25	CS-23 Normal CS-23 Commuter CS-25
Type of operation	part NCO part NCC	part NCO part NCC	part NCO part NCC	part NCO part NCC	part NCO part NCC Part CAT	part NCO part NCC Part CAT	part NCO part NCC Part CAT

TAWS: MCTOM > 5700 kg OR > 9 MPSC => CS-23 Normal category has no TAWS requirement;
ACAS: MTCOM > 5700 kg OR >19 MPSC => CS-23 Normal category and part of CS-23 Commuter category has no ACAS requirement.

5.3 Step 3: identification of gaps in the Certification Specifications, Flight Crew Licensing regulations and operations regulations

In this step it is identified where risk mitigation measures are missing and new regulations need to be developed and/or existing regulations need to be revised, based on the results of step 1 and comparison with identified FAA regulations from section 7.

The identified gaps in the Certification Specifications, Air Operations regulations and Flight Crew Licensing regulations are included in the tables of section 9.6.1 (to avoid unnecessary duplication in this document).

Notes with regard to gaps in the Certification Specifications:

It is assumed that CS-25 properly covers all possible technical mitigating measures against the identified incidents.
It should be noted that CS-LSA and CS-VLA aeroplane types with high performance do not exist, so there are nog gaps in CS-LSA and CS-VLA.

Notes with regard to gaps in the Flight Crew Licensing regulations:

All licences higher than PPL (CPL, ATPL) are considered to have enough mitigation elements for HPA, from a required pilot skill perspective.

For LAPL and PPL the following is noted:
- If the type is classified as single pilot/single engine piston HPA, some general requirements are specified in Part FCL for LAPL;
- If the type is specified as single pilot/single or multi engine HPA or multi pilot (type rating required) some general requirements are specified in Part FCL for PPL;
- If no class or type rating is required, there are no specific licencing requirements for high performance aircraft;
- Some class ratings (aerobatic, Instrument, mountain, Flight test) have elements with mitigating value for the operation of high performance aircraft;
- The incident “failure to timely detect failure in cabin pressurisation or supplemental oxygen system” is not mitigated for LAPL and PPL without type rating, as hypoxia training is not required;
- The incident “failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression is not mitigated for LAPL and PPL without type rating, as procedure training is not required.

There is a high degree of fragmentation in the requirements relative to High Performance Aircraft. The safety level of the operation of such aircraft may be compromised.
Also the EU regulations do not contain a specific rating for High Performance Aircraft.

A more streamlined regulation structure, including High Performance Aircraft as a specific rating, would be advisable in order to properly achieve a safety level for the operation of such aircraft.

6 Performance Classes versus high performance aircraft

This section describes the relation of the part CAT performance classes with high performance aircraft.

6.1 Part CAT performance classes

Part CAT states the following:

CAT.POL.A.100 Performance classes

(a) The aeroplane shall be operated in accordance with the applicable performance class requirements;

(b) Where full compliance with the applicable requirements of this Section cannot be shown due to specific design characteristics, the operator shall apply approved performance standards that ensure a level of safety equivalent to that of the appropriate chapter."

Annex I (Definitions) to Regulation (EU) No 965/2012 defines the various performance classes as follows:

Class A	Class B	Class C
• Multi engine turbo-prop, more than 9 persons + pilot(s); • Multi engine turbo-prop, more than 5700 kg; • Multi engine jet, more than 9 persons + pilot(s); • Multi engine jet, more than 5700 kg.	• Single engine piston, max 9 persons + pilot(s), max 5700 kg; • Single engine turbo-prop, max 9 persons + pilot(s), max 5700 kg; • Multi engine piston, max 9 persons + pilot(s), max 5700 kg; • Multi engine turbo-prop, max 9 persons + pilot(s), max 5700 kg.	• Single engine piston, more than 9 persons + pilot(s); • Single engine piston, more than 5700 kg; • Multi engine piston, more than 9 persons + pilot(s); • Multi engine piston, more than 5700 kg.
AMC/GM TO ANNEX IV (PART-CAT) SUBPART C — AIRCRAFT PERFORMANCE AND OPERATING LIMITATIONS **Section 1 — Aeroplanes** **Chapter 2 — Performance class A:** Performance Class A requires taking into account: • loss of available take-off runway length due to alignment; • take-off runway surface condition; • obstacle clearance minima for	**AMC/GM TO ANNEX IV (PART-CAT) SUBPART C — AIRCRAFT PERFORMANCE AND OPERATING LIMITATIONS** **Section 1 — Aeroplanes** **Chapter 3 — Performance class B** Performance Class B requires taking into account: • take-off runway slope; • take-off runway surface condition; • obstacle clearance minima for take-off including engine failure;	**AMC/GM TO ANNEX IV (PART-CAT) SUBPART C — AIRCRAFT PERFORMANCE AND OPERATING LIMITATIONS** **Section 1 — Aeroplanes** **Chapter 4 — Performance class C** Performance Class C requires taking into account: • loss of available take-off runway length due to alignment; • take-off runway slope; • take-off runway surface condition;

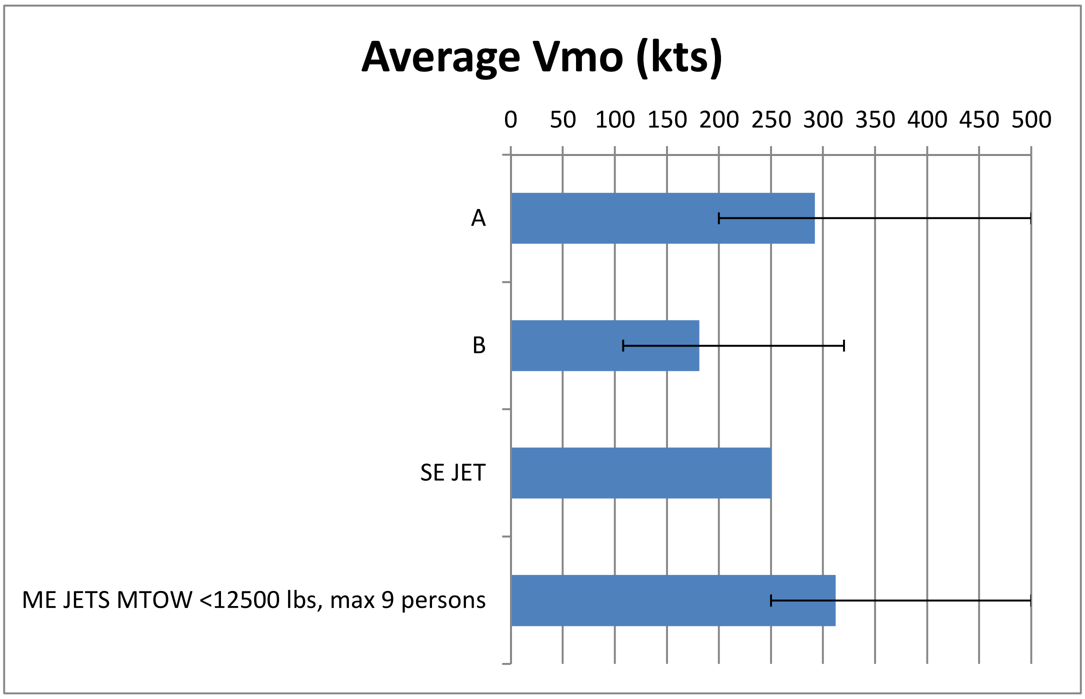
Class A	Class B	Class C
take-off including bank angles, engine failure; • obstacle clearance en-route in case of engine failure; • landing mass.	• obstacle clearance en-route in case of engine failure; • landing mass; • landing runway surface type; • landing runway surface condition; • landing runway slope.	• bank angles for obstacle clearance minima for take-off; • obstacle clearance en-route in case of engine failure; • landing mass; • landing runway surface type; • landing runway slope.

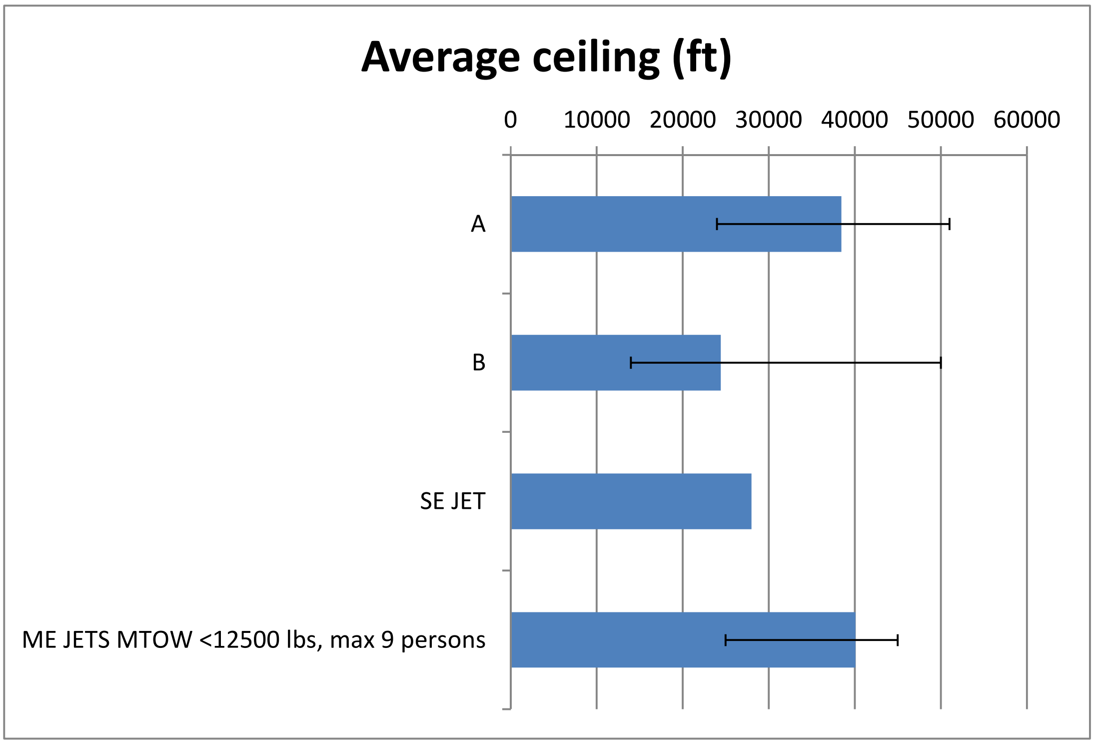
6.2 Relation with high performance aircraft

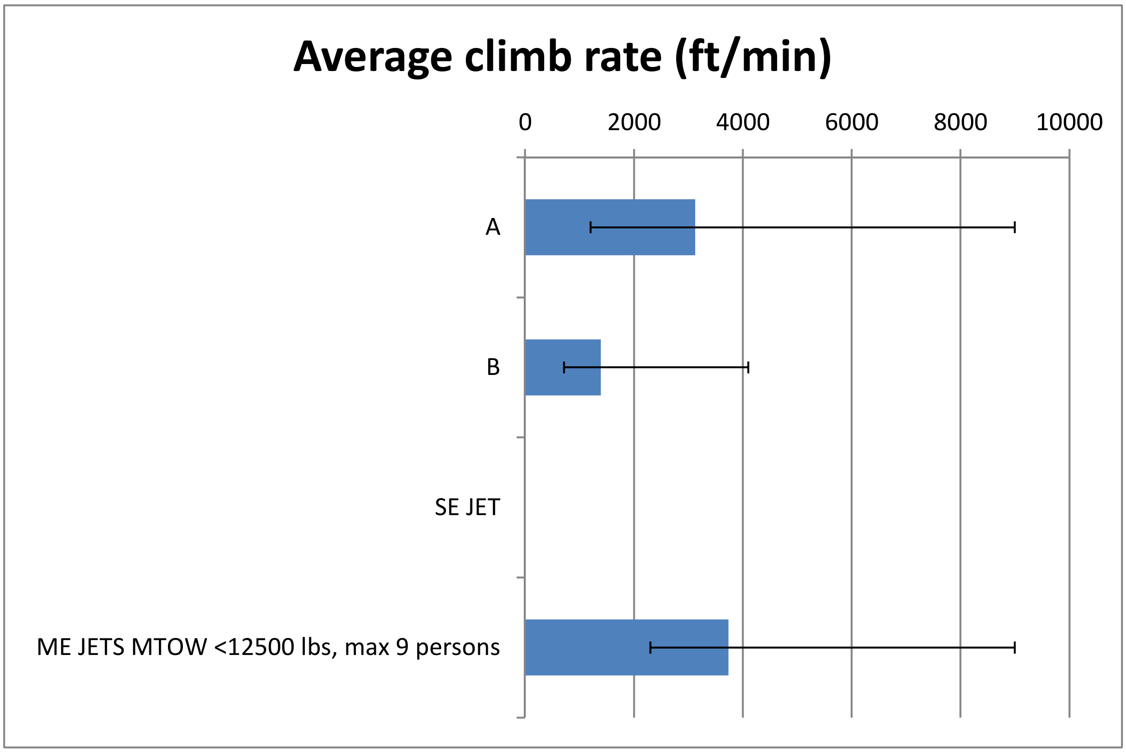
The part CAT performance classes have no relation with high performance. They are about ensuring sufficient take-off and landing runway lengths and route planning such that obstacles and terrain are avoided.

Bar charts that indicate the average (blue bar), minimum (left side of black line) and maximum performance (right side of black line) of aeroplane types within performance Class A and B have been produced (see below). Aeroplanes that fall within performance Class C could not be identified. The only thing that can be stated about performance is that the average performance of all aeroplanes that fall within performance class A is higher than those that fall within performance class B, and that individual aeroplane types within class B can have higher performance than individual aeroplane types within class A.

The performance of SE JETs and ME JETS with MTOW < 12,500 lbs, max 9 persons excluding the pilot(s), is also indicated, to support the identification of an appropriate performance class for these categories of aeroplanes.







6.3 Possible reason for having three different performance classes

It is not stated in the regulations what the justification behind the differences in regulations between the three performance classes is. What can be identified from section 6.2 is that Class A aeroplanes have, on average, higher performance than class B aeroplanes, although there are class B aeroplanes that have higher performance than Class A aeroplanes.

What also can be identified is (see table below) that:

- Class A is applicable to CS-23 Commuter and CS-25 aeroplanes;
- Class C is applicable to CS-23 Commuter aeroplanes;
- Class B is applicable to CS-23 Normal/Utility/Aerobatic, CS-LSA and CS-VLA aeroplanes.

Class A	Class B	Class C
• Multi engine turbo-prop, more than 9 persons + pilot(s) CS-23 Commuter, CS-25; • Multi engine turbo-prop, more than 5700 kg CS-23 Commuter, CS-25; • Multi engine jet, more than 9 persons + pilot(s) CS-23 Commuter, CS-25; • Multi engine jet, more than 5700 kg CS-23 Commuter, CS-25.	• Single engine piston, max 9 persons + pilot(s), max 5700 kg CS-LSA, CS-VLA, CS-23; • Single engine turbo-prop, max 9 persons + pilot(s), max 5700 kg CS-23; • Multi engine piston, max 9 persons + pilot(s), max 5700 kg CS-23; • Multi engine turbo-prop, max 9 persons + pilot(s), max 5700 kg CS-23.	• Single engine piston, more than 9 persons + pilot(s) No CS Category; • Single engine piston, more than 5700 kg No CS Category; • Multi engine piston, more than 9 persons + pilot(s) CS-23 Commuter; • Multi engine piston, more than 5700 kg CS-23 Commuter.

6.4 Aeroplane categories not covered by a performance class

From section 6.1 it follows that the following aircraft categories are not covered by a performance class:

- Single engine jet, max 9 persons + pilot(s), max 5700 kg;
- Single engine jet, more than 9 persons + pilot(s);
- Single engine jet, more than 5700 kg;
- Single engine turbo-prop with a maximum take-off mass exceeding 5 700 kg;
- Single engine turbo-prop with a maximum approved passenger seating configuration of more than 9;
- Twin engine jet, max 9 persons + pilot(s), max 5700 kg.

The following can be stated (see table below):

- Single engine jet, more than 9 persons + pilot(s):
  This aeroplane category is not allowed, as CS-23 Commuter or CS-25 in which such an aeroplane would fall, require twin engines;
- Single engine jet, more than 5700 kg:
  This aeroplane category is not allowed, as CS-23 Commuter or CS-25 in which such an aeroplane would fall, require twin engines;
- Single engine turbo-prop with a maximum take-off mass exceeding 5 700 kg:
  Aeroplanes that fall within this category could not be identified;
- Single engine turbo-prop with a maximum approved passenger seating configuration of more than 9:
  Aeroplanes that fall within this category could not be identified.

For the remaining two categories, the single and twin engine jet, max 9 persons + pilot(s), max 5700 kg, there the incidents that can be identified due to the absence of a performance class are:

- Runway excursion due to insufficient runway length margins used for take-off and landing;
- CFIT due to insufficient obstacle or terrain clearance margins used for climb and en-route flight phases.

The mitigating measure would be to put these aircraft categories in a performance class.

- For single engine jet, max 9 persons + pilot(s), max 5700 kg:
  The only aeroplane on the market today is the Cirrus Vision Jet which has performance similar to aeroplane types in Class B. Therefore the most fitting performance class for the Cirrus Vision Jet is Class B. Once a representative set of single engine jet aeroplane types become available, depending on their performance it can be reconsidered if an adapted class A would be appropriate. An adapted class A meaning class A excluding the engine failure accountability and excluding requirements to take loss of runway length due to alignment into account which is judged to be unnecessary for small aeroplanes;
- For twin engine jet, max 9 persons + pilot(s), max 5700 kg:
  Most fitting from a Certification Specification perspective would be Class B.
  Most fitting from a performance perspective would be Class A (current EASA practice).

CS-LSA **max 600 kg sea / 650 kg land** **max 2 persons**	**CS-VLA** **max 750 kg** **max 2 persons**	**CS-23 Normal / Utility / Aerobatic** **max 5670 kg / 12500 lb** **max 9 persons + pilot(s)**	**CS-23 Commuter** **max 8618 kg / 19000 lb** **max 19 persons + pilot(s)**	**CS-25** **Large Aeroplanes** **max 5700 kg / 12500 lb**
Single engine piston or electric Class B	Single engine piston Class B	• Single engine piston Class B; • Single engine turbo-prop Class B; • Twin engine piston Class B; • Twin engine turbo-prop Class B; • Single engine jet No Class; • Twin engine jet No Class.	• Twin engine piston Class B or Class C; • Twin engine turbo-prop Class B or Class A; • Twin engine jet (although not covered by CS-23 Commuter): - more than 9 persons + pilot(s) or more than 5700 kg: Class A; - max 9 persons + pilot(s), max 5700 kg: No Class.	• Multi-engine jet Class A; • Multi-engine turboprop Class A; • Multi-engine piston not covered (aeroplane category does not exist anymore).

7 Analysis of FAA and TCA regulatory frameworks on high performance aircraft

The FAA and TCA (Canada) regulatory frameworks have been analysed to see if they contain risk mitigating measures (regulations or guidance material) for high performance aircraft which lack in the European regulatory framework.

This has been used to support the identification high performance related incidents (in section 4) for which risk mitigation measures are missing in the European regulations (in section 5) and the definition of proposed safety recommendations (in section 9).

In this section the results are described.

7.1 FAA regulations for high performance aircraft

7.1.1 Additional training requirements

Additional training for high performance aircraft

14 CFR 61.31 - Type rating requirements, additional training, and authorization requirements
(f) Additional training required for operating high-performance airplanes.
(1) Except as provided in paragraph (f)(2) of this section, no person may act as pilot in command of a high-performance airplane (an airplane with an engine of more than 200 horsepower), unless the person has—
(i) Received and logged ground and flight training from an authorized instructor in a high-performance airplane, or in a flight simulator or flight training device that is representative of a high-performance airplane, and has been found proficient in the operation and systems of the airplane; and
(ii) Received a one-time endorsement in the pilot's logbook from an authorized instructor who certifies the person is proficient to operate a high-performance airplane.
(2) The training and endorsement required by paragraph (f)(1) of this section is not required if the person has logged flight time as pilot in command of a high-performance airplane, or in a flight simulator or flight training device that is representative of a high-performance airplane prior to August 4, 1997.
(g) Additional training required for operating pressurized aircraft capable of operating at high altitudes.
(1) Except as provided in paragraph (g)(3) of this section, no person may act as pilot in command of a pressurized aircraft (an aircraft that has a service ceiling or maximum operating altitude, whichever is lower, above 25,000 feet MSL), unless that person has received and logged ground training from an authorized instructor and obtained an endorsement in the person's logbook or training record from an authorized instructor who certifies the person has satisfactorily accomplished the ground training. The ground training must include at least the following subjects:
(i) High-altitude aerodynamics and meteorology;
(ii) Respiration;
(iii) Effects, symptoms, and causes of hypoxia and any other high-altitude sickness;
(iv) Duration of consciousness without supplemental oxygen;
(v) Effects of prolonged usage of supplemental oxygen;

(vi) Causes and effects of gas expansion and gas bubble formation;
(vii) Preventive measures for eliminating gas expansion, gas bubble formation, and high-altitude sickness;
(viii) Physical phenomena and incidents of decompression; and
(ix) Any other physiological aspects of high-altitude flight.
(2) Except as provided in paragraph (g)(3) of this section, no person may act as pilot in command of a pressurized aircraft unless that person has received and logged training from an authorized instructor in a pressurized aircraft, or in a flight simulator or flight training device that is representative of a pressurized aircraft, and obtained an endorsement in the person's logbook or training record from an authorized instructor who found the person proficient in the operation of a pressurized aircraft. The flight training must include at least the following subjects:
(i) Normal cruise flight operations while operating above 25,000 feet MSL;
(ii) Proper emergency procedures for simulated rapid decompression without actually depressurizing the aircraft; and
(iii) Emergency descent procedures.
(3) The training and endorsement required by paragraphs (g)(1) and (g)(2) of this section are not required if that person can document satisfactory accomplishment of any of the following in a pressurized aircraft, or in a flight simulator or flight training device that is representative of a pressurized aircraft:
(i) Serving as pilot in command before April 15, 1991;
(ii) Completing a pilot proficiency check for a pilot certificate or rating before April 15, 1991;
(iii) Completing an official pilot-in-command check conducted by the military services of the United States; or
(iv) Completing a pilot-in-command proficiency check under part 121, 125, or 135 of this chapter conducted by the Administrator or by an approved pilot check airman.
(h) Additional aircraft type-specific training. No person may serve as pilot in command of an aircraft that the Administrator has determined requires aircraft type-specific training unless that person has—
(1) Received and logged type-specific training in the aircraft, or in a flight simulator or flight training device that is representative of that type of aircraft; and
(2) Received a logbook endorsement from an authorized instructor who has found the person proficient in the operation of the aircraft and its systems.

Summary:
The FAA requires a logbook endorsement that the person operating a high performance (and pressurized) aircraft has received additional training. Although the requirement is not specifying a type rating, the training requirements are logically located and apply to any HPA. The downside is that a HPA is defined as an aircraft with engine power more than 200 HP, which seems to be a very limited definition.

7.1.2 Additional operational requirements

Single pilot wearing oxygen mask at high altitude

FAR §91.211Supplemental oxygen
(a) General. No person may operate a civil aircraft of U.S. registry—
(1) At cabin pressure altitudes above 12,500 feet (MSL) up to and including 14,000 feet (MSL) unless the required minimum flight crew is provided with and uses supplemental oxygen for that part of the flight at those altitudes that is of more than 30 minutes duration;

(2) At cabin pressure altitudes above 14,000 feet (MSL) unless the required minimum flight crew is provided with and uses supplemental oxygen during the entire flight time at those altitudes; and
(3) At cabin pressure altitudes above 15,000 feet (MSL) unless each occupant of the aircraft is provided with supplemental oxygen.
(b) Pressurized cabin aircraft. (1) No person may operate a civil aircraft of U.S. registry with a pressurized cabin—
(i) At flight altitudes above flight level 250 unless at least a 10-minute supply of supplemental oxygen, in addition to any oxygen required to satisfy paragraph (a) of this section, is available for each occupant of the aircraft for use in the event that a descent is necessitated by loss of cabin pressurization; and
(ii) At flight altitudes above flight level 350 unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed and that either supplies oxygen at all times or automatically supplies oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000 feet (MSL), except that the one pilot need not wear and use an oxygen mask while at or below flight level 410 if there are two pilots at the controls and each pilot has a quick-donning type of oxygen mask that can be placed on the face with one hand from the ready position within 5 seconds, supplying oxygen and properly secured and sealed.
(2) Notwithstanding paragraph (b)(1)(ii) of this section, if for any reason at any time it is necessary for one pilot to leave the controls of the aircraft when operating at flight altitudes above flight level 350, the remaining pilot at the controls shall put on and use an oxygen mask until the other pilot has returned to that crewmember's station.

Summary:
The FAA also requires a single pilot in the cockpit to wear an oxygen mask in certain high altitude conditions.

7.1.3 Additional airworthiness requirements

Rapid decompression – structure requirements

FAR §23.571 Metallic pressurized cabin structures
(d) If certification for operation above 41,000 feet is requested, a damage tolerance evaluation of the fuselage pressure boundary per §23.573(b) must be conducted.

FAR §23.573 Damage tolerance and fatigue evaluation of structure
(b) Metallic airframe structure. If the applicant elects to use §23.571(c) or §23.572(a)(3), then the damage tolerance evaluation must include a determination of the probable locations and modes of damage due to fatigue, corrosion, or accidental damage. Damage at multiple sites due to fatigue must be included where the design is such that this type of damage can be expected to occur. The evaluation must incorporate repeated load and static analyses supported by test evidence. The extent of damage for residual strength evaluation at any time within the operational life of the airplane must be consistent with the initial detectability and subsequent growth under repeated loads. The residual strength evaluation must show that the remaining structure is able to withstand critical limit flight loads, considered as ultimate, with the extent of detectable damage consistent with the results of the damage tolerance evaluations. For pressurized cabins, the following load must be withstood:
(1) The normal operating differential pressure combined with the expected external aerodynamic pressures applied simultaneously with the flight loading conditions specified in this part, and
(2) The expected external aerodynamic pressures in 1g flight combined with a cabin differential pressure equal to 1.1 times the normal operating differential pressure without any other load.

Summary:
For flight above 41,000 feet MSL, FAR §23.571 (d) requires a damage tolerance evaluation of the fuselage pressure boundary per FAR § 23.573(b) must be conducted for cabin rupture as a discrete case. CS-23 does not require this.

Rapid decompression - cabin altitude limits

CS 23.841 Pressurised cabins
(a) If certification for operation over 7620m (25 000 ft) is requested, the aeroplane must be able to maintain a cabin pressure altitude of not more than 4572m (15 000 ft) in event of any probable failure or malfunction in the pressurisation system.

FAR §23.841 Pressurized cabins
(a) If certification for operation above 25,000 feet is requested, the airplane must be able to maintain a cabin pressure altitude of not more than 15,000 feet, in the event of any probable failure condition in the pressurization system. During decompression, the cabin altitude may not exceed 15,000 feet for more than 10 seconds and 25,000 feet for any duration.

Summary:
FAR §23.841 has limits in cabin altitude during decompressions that are not in CS-23.

Rapid decompression between 41,000 and 45,000 ft – cabin altitudes limits

FAR §23.841 Pressurized cabins
(c) If certification for operation above 41,000 feet and not more than 45,000 feet is requested—
(1) The airplane must prevent cabin pressure altitude from exceeding the following after decompression from any probable pressurization system failure in conjunction with any undetected, latent pressurization system failure condition:
(i) If depressurization analysis shows that the cabin altitude does not exceed 25,000 feet, the pressurization system must prevent the cabin altitude from exceeding the cabin altitude-time history shown in Figure 1 of this section.
(ii) Maximum cabin altitude is limited to 30,000 feet. If cabin altitude exceeds 25,000 feet, the maximum time the cabin altitude may exceed 25,000 feet is 2 minutes; time starting when the cabin altitude exceeds 25,000 feet and ending when it returns to 25,000 feet.
(2) The airplane must prevent cabin pressure altitude from exceeding the following after decompression from any single pressurization system failure in conjunction with any probable fuselage damage:
(i) If depressurization analysis shows that the cabin altitude does not exceed 37,000 feet, the pressurization system must prevent the cabin altitude from exceeding the cabin altitude-time history shown in Figure 2 of this section.
(ii) Maximum cabin altitude is limited to 40,000 feet. If cabin altitude exceeds 37,000 feet, the maximum time the cabin altitude may exceed 25,000 feet is 2 minutes; time starting when the cabin altitude exceeds 25,000 feet and ending when it returns to 25,000 feet.
(3) In showing compliance with paragraphs (c)(1) and (c)(2) of this section, it may be assumed that an emergency descent is made by an approved emergency procedure. A 17-second flight crew recognition and reaction time must be applied between cabin altitude warning and the initiation of an emergency descent. Fuselage structure, engine and system failures are to be considered in evaluating the cabin decompression.

Summary:

FAR §23.841 has requirements for operations above 41,000 feet and up to 45,000 feet MSL, including limits in cabin altitude during decompression, that are not in CS-23.

Rapid decompression between 45,000 ft and 51,000 ft – cabin altitudes limits

FAR §23.841 Pressurized cabins

d) If certification for operation above 45,000 feet and not more than 51,000 feet is requested—
(1) Pressurized cabins must be equipped to provide a cabin pressure altitude of not more than 8,000 feet at the maximum operating altitude of the airplane under normal operating conditions.
(2) The airplane must prevent cabin pressure altitude from exceeding the following after decompression from any failure condition not shown to be extremely improbable:
(i) Twenty-five thousand (25,000) feet for more than 2 minutes; or
(ii) Forty thousand (40,000) feet for any duration.
(3) Fuselage structure, engine and system failures are to be considered in evaluating the cabin decompression.
(4) In addition to the cabin altitude indicating means in (b)(6) of this section, an aural or visual signal must be provided to warn the flight crew when the cabin pressure altitude exceeds 10,000 feet.
(5) The sensing system and pressure sensors necessary to meet the requirements of (b)(5), (b)(6), and (d)(4) of this section and §23.1447(e), must, in the event of low cabin pressure, actuate the required warning and automatic presentation devices without any delay that would significantly increase the hazards resulting from decompression.

Summary:

FAR §23.841 has requirements for operations above 45,000 feet and not more than 51,000 feet MSL, including limits in cabin altitude during decompression, that are not in CS-23.

Rapid decompression above 41,000 ft – continuous flow oxygen system for each passenger

FAR §23.1443 Minimum mass flow of supplemental oxygen

(a) If the airplane is to be certified above 41,000 feet, a continuous flow oxygen system must be provided for each passenger.

Summary:

FAR §23.1443 requires continuous flow oxygen systems for passengers in airplanes with operations above 41,000 feet MSL. CS-23.1443 allows a choice between continuous flow oxygen systems and first-aid oxygen equipment.

Rapid decompression above 41,000 ft – quick-donning oxygen mask system for flight crew

FAR §23.1447 Equipment standards for oxygen dispensing units

(g) If the airplane is to be certified for operation above 41,000 feet, a quick-donning oxygen mask system, with a pressure demand, mask mounted regulator must be provided for the flight crew. This dispensing unit must be immediately available to the flight crew when seated at their station and installed so that it:
(1) Can be placed on the face from its ready position, properly secured, sealed, and supplying oxygen upon demand, with one hand, within five seconds and without disturbing eyeglasses or causing delay in proceeding with emergency duties; and
(2) Allows, while in place, the performance of normal communication functions.

Summary:

FAR §23.1447 has requirements for crew oxygen equipment in airplanes with operations above 41,000 feet MSL. CS-23 does not.

Operation above 41,000 ft - air quality

FAR §23.573 Ventilation

(c) For jet pressurized airplanes that operate at altitudes above 41,000 feet, under normal operating conditions and in the event of any probable failure conditions of any system which would adversely affect the ventilating air, the ventilation system must provide reasonable passenger comfort. The ventilation system must also provide a sufficient amount of uncontaminated air to enable the flight crew members to perform their duties without undue discomfort or fatigue. For normal operating conditions, the ventilation system must be designed to provide each occupant with at least 0.55 pounds of fresh air per minute. In the event of the loss of one source of fresh air, the supply of fresh airflow may not be less than 0.4 pounds per minute for any period exceeding five minutes.

(d) For jet pressurized airplanes that operate at altitudes above 41,000 feet, other probable and improbable Environmental Control System failure conditions that adversely affect the passenger and flight crew compartment environmental conditions may not affect flight crew performance so as to result in a hazardous condition, and no occupant shall sustain permanent physiological harm.

Summary:

FAR §23.573 has ventilation requirements for operations above 41,000 feet MSL that are not in CS-23.

Cabin pressurisation system – resetting warning of cabin altitude at high altitude airports

CS 23.841 Pressurised cabins

(b) Pressurised cabins must have at least the following valves, controls and indicators, for controlling cabin pressure.

(6) Warning indication at the pilot station to indicate when the safe or pre-set pressure differential is exceeded and when a cabin pressure altitude of 3048m (10 000 ft) is exceeded.

FAR §23.841 Pressurized cabins

(b) Pressurized cabins must have at least the following valves, controls, and indicators, for controlling cabin pressure:

(6) Warning indication at the pilot station to indicate when the safe or preset pressure differential is exceeded and when a cabin pressure altitude of 10,000 feet is exceeded. The 10,000 foot cabin altitude warning may be increased up to 15,000 feet for operations from high altitude airfields (10,000 to 15,000 feet) provided:

Summary:

FAR §23.841 allows resetting the warning of cabin altitude above 10,000 feet MSL when taking off or landing at high altitude airports. CS-23 does not allow this.

High altitude – procedures for engine restart

FAR §23.1585 Operating procedures

(a) For all airplanes, information concerning normal, abnormal (if applicable), and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including—

(4) Procedures for restarting any turbine engine in flight, including the effects of altitude; and

Summary:

FAR §23.1585 requires procedures for restarting any engine in flight including the effects of altitude. CS-23 has no similar requirement.

High altitude – battery capacity in case of loss of the primary electrical power generating system

FAR §23.1353 Storage battery design and installation

(h)(1) In the event of a complete loss of the primary electrical power generating system, the battery must be capable of providing electrical power to those loads that are essential to continued safe flight and landing for:

(ii) At least 60 minutes for airplanes that are certificated with a maximum altitude over 25,000 feet.

Summary:

FAR §23.1353 requires 60 minutes battery capacity for all airplanes with a service ceiling above 25,000 feet. CS-23 requires 30 minutes.

High altitude / high speed stall (coffin corner) – recovery characteristics

FAR §23.201 Wings level stall

(e) For airplanes approved with a maximum operating altitude at or above 25,000 feet during the entry into and the recovery from stalls performed at or above 25,000 feet, it must be possible to prevent more than 25 degrees of roll or yaw by the normal use of controls.

Summary

FAR §23.201 requires recovery from wings level stall above 25,000 without exceeding roll and yaw angles of 25 degrees CS-23 has no corresponding requirement.

Single engine propeller aeroplanes – stall

FAR §23.691 Artificial stall barrier system

If the function of an artificial stall barrier, for example, stick pusher, is used to show compliance with §23.201(c), the system must comply with the following:

(a) With the system adjusted for operation, the plus and minus airspeeds at which downward pitching control will be provided must be established.

(b) Considering the plus and minus airspeed tolerances established by paragraph (a) of this section, an airspeed must be selected for the activation of the downward pitching control that provides a safe margin above any airspeed at which any unsatisfactory stall characteristics occur.

(c) In addition to the stall warning required §23.07, a warning that is clearly distinguishable to the pilot under all expected flight conditions without requiring the pilot's attention, must be provided for faults that would prevent the system from providing the required pitching motion.

(d) Each system must be designed so that the artificial stall barrier can be quickly and positively disengaged by the pilots to prevent unwanted downward pitching of the airplane by a quick release (emergency) control that meets the requirements of §23.1329(b).

(e) A preflight check of the complete system must be established and the procedure for this check made available in the Airplane Flight Manual (AFM). Preflight checks that are critical to the safety of the airplane must be included in the limitations section of the AFM.

(f) For those airplanes whose design includes an autopilot system:

(1) A quick release (emergency) control installed in accordance with §23.1329(b) may be used to meet the requirements of paragraph (d), of this section, and

(2) The pitch servo for that system may be used to provide the stall downward pitching motion.
(g) In showing compliance with §23.1309, the system must be evaluated to determine the effect that any announced or unannounced failure may have on the continued safe flight and landing of the airplane or the ability of the crew to cope with any adverse conditions that may result from such failures. This evaluation must consider the hazards that would result from the airplane's flight characteristics if the system was not provided, and the hazard that may result from unwanted downward pitching motion, which could result from a failure at airspeeds above the selected stall speed.

CS 23.201 Wings level stall

(b) The wings level stall characteristics must be demonstrated in flight as follows. Starting from a speed at least 18.5 km/h (10 knots) above the stall speed, the elevator control must be pulled back so that the rate of speed reduction will not exceed 1.9 km/h (one knot) per second until a stall is produced, as shown by either –
(1) An uncontrollable downward pitching motion of the aeroplane; or
(2) A downward pitching motion of the aeroplane which results from the activation of a device (e.g. stick pusher); or
(3) The control reaching the stop.
(c) Normal use of elevator control for recovery is allowed after the downward pitching motion of (b) (1) or (b) (2) has unmistakably been produced, or after the control has been held against the stop for not less than the longer of 2 seconds or the time employed in the minimum steady flight speed determination of CS 23.49.

Summary:

FAR §23.691 allows aeroplanes to use an artificial stall barrier system to comply with §23.201(c) EASA CS-23 does not allow this.

Twin engine aeroplanes - procedures for engine failure during take-off

FAR §23.1585 Operating procedures

(a) For all airplanes, information concerning normal, abnormal (if applicable), and emergency procedures and other pertinent information necessary for safe operation and the achievement of the scheduled performance must be furnished, including—
(f) In addition to paragraphs (a) and (c) of this section, for normal, utility, and acrobatic category multiengine jets weighing over 6,000 pounds, and commuter category airplanes, the information must include the following:
(3) Procedures and speeds for continuing a take-off following engine failure in accordance with §23.59(a)(1) and for following the flight path determined under §23.57 and §23.61(a).

Summary:

Operating procedures for all part 23 aeroplanes over 6,000 pounds and commuter category, must include procedures and speeds for continuing a take-off following engine failure. CS-23 requires this only for commuter category aeroplanes.

Twin engine aeroplanes – engine failure during take-off – minimum control speeds

CS 23.1513 Minimum control speed

The minimum control speed(s) VMC, determined under CS 23.149 (b), must be established as an operating limitation(s).

FAR §23.1513 Minimum control speed

The minimum control speed V_{MC}, determined under §23.149, must be established as an operating limitation.

Summary:

FAR §23.1513 references all of 23.149. CS 23.1513 references only CS 23.149(b).

7.2 TCA (Canada) regulations for high performance aircraft

7.2.1 Additional training requirements

Additional training for high performance aircraft

CAR 2015-1 / Standard 421 / Appendix A

Describes High Performance Aeroplanes in subsection 400.01(1) combined with a list of examples.

CARS 421.40 (3)(c)

(c) High Performance Aeroplane

(i) Knowledge

An applicant for an individual aircraft type rating for a high performance aeroplane shall have completed ground training on the aeroplane type.

(ii) Experience

An applicant shall have completed flight training and have acquired a minimum of 200 hours pilot flight time on aeroplanes.

(iii) Skill

Within the 12 months preceding the date of application for the rating, an applicant shall have successfully completed a qualifying flight under the supervision of a Transport Canada Inspector or a qualified person qualified in accordance with CAR 425.21(7)(a).

(amended 1999/03/01; previous version)

(7) A person who conducts flight training toward the issuance of an aircraft type rating shall:

(a) in the case of training for a holder of an aeroplane pilot permit or pilot licence:

(amended 2006/12/14)

(i) be the holder of a Commercial Pilot Licence - Aeroplane or an Airline Transport Pilot Licence - Aeroplane; and

(amended 2005/12/01)

(ii) have experience of not less than 50 hours flight time on the class of aeroplane used for the training, of which not less than 10 hours must be on the aeroplane type;

Part IV - Personnel Licensing and Training

Canadian Aviation Regulations (CARs) 2015-1

Standard 421 – Flight Crew Permits, Licences and Ratings

Appendix A – Aircraft Type Designators - High Performance Aeroplanes

Aeroplane Types - High Performance

Note: High performance aeroplane – as defined in subsection 400.01(1) of the CARs.

“high-performance aeroplane”, with respect to a rating, means

(*a*) an aeroplane that is specified in the minimum flight crew document as requiring only one pilot and that has a maximum speed (V_{ne}) of 250 KIAS or greater or a stall speed (V_{so}) of 80 KIAS or greater, or

(*b*) an amateur-built aeroplane that has a wing loading greater than that specified in section 549.103 of the *Airworthiness Manual*; (*avion à hautes performances*)

Summary:

TCA requires a specific rating for a high performance aircraft with training and currency requirements. Although the definition of a HPA seems somewhat restrictive (covers only approach speed and maximum speed performance parameters), the Canadian approach may be the most straightforward in the industry.

8 Analysis of safety data (Robert Breiling, NTSB, EDA) on high performance aircraft

Safety studies on high performance aircraft, as well as accident / incident statistics & reports, have been analysed for causal factors (hazards) related to high performance and for safety recommendations. This has supported the identification high performance related incidents (in section 4) for which risk mitigation measures are missing in the European regulatory framework (in section 5) and the definition of proposed safety recommendations in section 9).
In this section the results are described.

8.1 Safety studies on high performance aircraft

Very few safety studies could be found that are related to high performance aircraft. Some studies or papers refer to one specific aircraft model (e.g. the MU-2). Others look at general safety statistics.

Robert Breiling for instance has studied (ref.5) the safety performance of single engine turboprop aircraft by comparing it to twin propeller aircraft during the period 1985 – 2013. Aircraft like the TBM 700/850, PC-12 and PA-46-500TP which are currently classified as high performance aircraft by EASA were considered by Breiling. The main reason for the analysis conducted by Breiling originates from the concern that single engine turbo prop aircraft would have a higher accident rate than twin engine turbo prop aircraft. Also the Cessna CE-208 is considered by Breiling, however, this aircraft is not classified as HPA by EASA. The analysis done by Breiling are for US and Canadian registered aircraft. The Breiling studies are limited to safety performance statistics. No analysis of e.g. causal factors is conducted. The data analyse by Breiling show that the safety performance (in terms of an accident rate) of the individual aircraft models vary, most likely due to the small sample size which introduces statically larger variations. However, when grouped together the safety performance of the single turbo prop HPA aircraft is comparable to that of twin turbo prop aircraft according to the data collected by Breiling as they show no statistical significant difference.

A more relevant study regarding high performance aircraft safety was conducted by **Bureau d'Enquêtes et d'Analyses** pour la sécurité de l'aviation civile BEA (ref.4). The BEA analysed loss of control accidents with TBM 700 aircraft that occurred between 1990 and 2010 in France. The TBM 700 (and 850) aircraft is classified by EASA as a high performance aircraft. It is a pressurised single-engine turboprop. The BEA recorded thirty-six accidents involving the TBM 700 between the beginning of 1990 and March 2010. Nineteen could be classified in the category of loss of control in flight without any technical failures. The purpose of the BEA study was to identify the factors related to the loss of control accidents with the TBM 700. Two thirds of the events studied occurred in conditions of poor visibility. In the majority of cases, the flight was executed in minimum operational weather conditions, like fog, and heavy icing. Four accidents occurred following a stall at low speed on landing. Two accidents were subsequent to spatial disorientation leading to loss of control of the aircraft. Two accidents were related to inadequate taking into account of a cross wind on landing. The other losses of control occurred on final approach, close to the ground, and involved banking to the left during arrival. These accidents occurred at a low speed in a landing configuration followed by a rapid increase in thrust. Increasing power from idle at low speed can result in an unusual aerodynamic behaviour of the aircraft. These aerodynamic effects can cause a yaw and rolling moment and are typical of all forward-mounted high powered propeller driven single-engine aircraft. The yawing moments produced by the propeller are mainly caused by the spiralling slipstream which strikes the fuselage aft of the aircraft's centre of gravity, and from the slipstream striking the vertical stabilizer. Spiralling slipstream effects are the strongest at slow speed and high power settings. Another factor that introduces a yawing moment is asymmetrical thrust on a single engine propeller aircraft in which the down going blade pushes more air back than the up going blade. During high angles of attack, the descending blade produces more thrust than the ascending blade. This effect is greater with increasing horsepower and large propeller sizes. Rudder is needed to counteract the yawing moment produced by spiralling slipstream and asymmetrical thrust. As a result the aircraft will fly with some sideslip to be in equilibrium. A sideslip may induce a rolling moment with power-on because the slipstream then strikes more wing area at one side of the fuselage generating more lift at this side due to the local higher dynamic pressures. Finally vestibular disorientation was also considered by the BAE as factors in the loss of control cases with the TBM 700. The BEA study recommended that in order to prevent the accidents with the TBM 700, the training should be extended into various areas, such as: aircraft use at low speed; deterioration in the level of pilot performance at the end of a flight, as much for private pilots as for professionals; and raising pilot awareness of managing personal resources.

8.2 Analysis of accidents and incidents

In order to gain more insight in the safety issues related to high performance aircraft, a sample of occurrences with high performance aircraft as well as aircraft currently not classified as high performance aircraft according to EASA, was analysed. The analysis is limited to occurrences that took place in the U.S (source: **NTSB**). Although European occurrence data are also available, the completeness and level of detail of the information for many of the smaller high performance aircraft was insufficient for analysis. As the operation of high performance aircraft in the U.S. could be different from that in Europe, some of the results could not be applicable to the situation in Europe. However, it was found that for instance the aircraft operating manuals of HPA do not show significant differences from those used in Europe. Training and air traffic control, however, could be different in the U.S.

Using the U.S. data the differences in the causes of the occurrences of HPA and non HPA were identified. The data sample contained 1162 occurrences with aircraft currently classified as HPA by EASA (these are all certified under part 23), and 2640 occurrences classified as non HPA (these are mainly aircraft certified under part 25). The occurrences took place in a period from 1982 until 2015. 29% of the occurrences with HPA were fatal accidents with in total 1328 fatalities. Factors considered to be causal or contributable to the occurrences were compared for both HP and non HP aircraft by looking at the frequency of occurrence of each factor[1]. Factors identified in high performance aircraft events that had a significantly[2] higher frequency of occurrence than in occurrences with non HPA are listed in Table 8.1. Note that some factors were excluded as they were not related to the aircraft design or its operation (e.g. the lack of fire services at an airport was a significant factor in HPA occurrences, which has nothing to do with the aircraft).

The listed factors can be grouped into:
- Air traffic;

[1] Frequency was based on the overall number of factors identified in all occurrences in the HPA sample or the non HPA sample.

[2] It is assumed for this study that the difference should be at least a factor 2 and the absolute number of factors should be large enough (e.g. not 2 against 1 factor).

- Aircraft performance & control;
- Human factors; and
- Environment.

Under air traffic, factors like clearance not attained, altitude not maintained, and IFR procedures not followed are found. These could be related to high workload and experience of the pilot. A large number of factors are found under aircraft performance and control. Issues like not maintaining the proper speed (e.g. flying below Vso or Vmc[3]), long landings, and not maintaining of directional control are found much more frequent with high performance aircraft. Also overloading of the airframe is a significant factor with high performance aircraft. These events were mostly related to an encounter with severe turbulence or an abrupt manoeuvre conducted by the pilot (often during a loss of control). Under human factors, issues like poor decision making, poor planning, and not adhering to procedures are listed. These factors could be related to the other factors identified here. Under environment, factors like dawn light conditions (attributes to visual illusions), and drizzle/mist are found. However, some caution must be taken as the exposure to these conditions is not taken into account here.

Table 8.1 Significant factors in occurrences with high performance aircraft

Significant Factor in occurrences with high performance aeroplanes
BELOW AIRSPEED(V_{SO})
CLEARANCE-NOT ATTAINED
EMERGENCY PROCEDURE-SIMULATED
GEAR EXTENSION-NOT PERFORMED
BELOW AIRSPEED(VMC)
AIRSPEED-MISJUDGED
DISTANCE/SPEED-MISJUDGED
EMERGENCY PROCEDURE-NOT FOLLOWED
IN-FLIGHT PLANNING/DECISION-INADEQUATE
PROPER ALTITUDE-NOT MAINTAINED
IFR PROCEDURE-IMPROPER
ALTITUDE/CLEARANCE-NOT MAINTAINED
DESIGN STRESS LIMITS OF AIRCRAFT-EXCEEDED (36% due to abrupt manoeuvre most of the time during loss of control)
FUEL-STARVATION
OPERATION WITH KNOWN DEFICIENCIES IN EQUIPMENT-PERFORMED
WEATHER CONDITION-DRIZZLE/MIST
STALL/SPIN or MUSH-INADVERTENT
AIRCRAFT CONTROL-NOT MAINTAINED/ NOT POSSIBLE
ALTITUDE-MISJUDGED
LIGHT CONDITION-DAWN
CHECKLIST-NOT FOLLOWED
PROPER TOUCHDOWN POINT-NOT ATTAINED
IN-FLIGHT PLANNING/DECISION-POOR

Based on expert judgement, these significant factors in occurrences with high performance aeroplanes are related to the identified high performance related incidents as follows:

[3] Vmc issues only relate to multi engine aircraft. However, the comparison here is not exclusively made for multi engine aircraft.

Table 8.2 Identified highy performance related incidents versus identified factors (NTSB data)

Aeroplane characteristic	Identified high performance related incidents	Significant Factor in occurrences with high performance aeroplanes
Speed brake present	- Speed brake extended in flight regime where this is not permitted => stall	- not confirmed.
Vmo / Mmo	Lagging behind events due to high speed => late communication to other crew members.	- not confirmed.
	Lagging behind events due to high speed => late reporting to ATC –	- not confirmed.
	Lagging behind events due to high speed => airspace infringement.	- clearance not attained, altitude misjudged, proper altitude not maintained, altitude / clearance not maintained.
	Lagging behind events due to high speed => improper navigation in the vicinity of terrain (CFIT).	- not confirmed.
	Lagging behind events due to high speed => failure to extend landing gear.	- gear extension not performed.
	Fuel starvation (poor flight planning) due to large variation of fuel consumption with altitude.	- fuel starvation due to poor flight planning.
	Exceeding M_{MO} and high speed buffet => high speed stall.	- not confirmed.
	Exceeding maximum operating altitude and flight near the coffin corner => low speed and/or high speed stall.	- not confirmed.
V_{REF} at MLAW	Hard landing due to high approach speed.	- design stress limits of aircraft exceeded.
	Long landing due to high approach speed.	- airspeed misjudged; - distance / speed misjudged; - proper touchdown point not attained.
Max climb rate	Level bust due to high climb rate.	- altitude misjudged, proper altitude not maintained.
	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system => hypoxia	- not confirmed. - not confirmed.

Aeroplane characteristic	Identified high performance related incidents	Significant Factor in occurrences with high performance aeroplanes
Steep approach capability	Hard landing due to steep approach. Undershoot due to steep approach.	- not confirmed; - not confirmed.
Service ceiling	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system => hypoxia. Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression. Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing is exhausted, in case of loss of primary electrical power generating system at high altitude. Reduced flight crew performance due to poor ventilation at high altitude.	- not confirmed. - not confirmed. - not confirmed. - not confirmed.
Engine power on single engine propeller aeroplanes, weight	Loss of control after applying power at low speeds near the stall (e.g. during approach or go-around) on single engine propeller aeroplanes with high power to weight ratio.	• aircraft control not maintained; • stall / spin or mush inadvertent; • below airspeed (Vso); • below airspeed (VMC); • light condition – dawn; • weather condition – drizzle mist.
Twin engines Margin between Vs1 and Vmca Margin between Vs1 and Vmcg Margin between Vs1 and Vr	Loss of control after engine failure on the ground or in flight on multi-engine aeroplane.	• aircraft control not maintained; • stall / spin or mush inadvertent; • below airspeed (Vso); • below airspeed (VMC); • light condition – dawn; • weather condition – drizzle mist; • design stress limits of aircraft exceeded due to abrupt manoeuvre during loss of control.

This confirms some of the identified high performance related incidents, but also shows that some incidents do not occur in the U.S in practice, which is most likely due to:

- Adequate FAA regulations being in place for:
  - Late communication to other crew members;
  - Late reporting to ATC;
  - In case of M_{MO}: high speed buffet, and when exceeding the maximum operating altitude the encounter of high speed stalls;

- Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression => hypoxia.

- Adequate FAA CRI's being defined:
  - Failure to timely detect failure in cabin pressurisation or supplemental oxygen system => hypoxia;
  - Hard landing after steep approach => runway excursion of aircraft damage;
  - Undershoot in steep approach.
- The less intense flying environment in the U.S, which results in a generally lower workload than in Europe:
  - ACAS alert due to high climb rate.
- The absence of speed brakes on the considered aeroplanes for:
  - Speed brake extended in flight regime where this is not permitted => stall.
- The fact that many high performance aeroplanes have TAWS installed even if this is not required by the air operations regulations:
  - Improper navigation in the vicinity of terrain (CFIT).

9 Preliminary Regulatory Impact Assessment

In order to assess whether further rulemaking regarding high performance aircraft could be necessary, a Preliminary Regulatory Impact Assessment is executed. This pre-RIA should answer the following question: Is rulemaking necessary or should the issue better be addressed by other means? In the next sections basically follow the steps of the EASA pre-RIA template[4] and contains the following elements:

- Analysis of the issue and current regulatory framework;
- Stakeholders affected;
- Safety risk assessment;
- Baseline assessment;
- Objectives;
- Options, preliminary impacts and recommended action; and
- Complexity and controversy.

9.1 Analysis of the issue and current regulatory framework

There used to be a clear relationship between weight of an aeroplane with certain types of propulsion, and its performance. Due to technological developments this classic relationship is no longer valid. This means that aeroplane types with substantially higher performance than other aeroplane types that can be operated with certain pilot licenses and/or, fall within certain certification specifications and/or fall under certain operations regulations, have come onto the market.

In section 4, 22 potential incidents related to high performance aeroplanes have been identified based on expert judgement.

In section 8 it has been assessed, by comparing a sample of occurrences with high performance aeroplanes (as currently classified by EASA) with aeroplanes not classified as high performance aeroplanes, whether these identified potential incidents actually occur more often in practice with high performance aeroplanes than with non-high performance aeroplanes in the United States during the period 1982-2013. Part of the identified high performance related incidents are confirmed. The occurrence rates could not be determined as the number of flights or flight hours is not known for the data samples taken.

Some incidents are not confirmed, which is most likely due to:

- Adequate FAA regulations being in place;
- Adequate FAA CRI's being defined;
- The less intense flying environment in the U.S, which results in a generally lower workload than in Europe;
- The absence of speed brakes on the considered aeroplanes;
- The fact that many high performance aeroplanes have TAWS installed even if this is not required by the air operations regulations.

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4 http://easa.europa.eu/system/files/dfu/rulemaking-docs-procedures-and-work-instructions-TE-RMP-00037-002-Pre-RIA.pdf.

This means that all of the 22 identified incident types remain relevant in the sense that it must be assessed whether adequate mitigation in the current regulatory framework in Europe is in place.

In section 5 the gaps in the regulations (insufficient mitigation in the current regulatory framework) with respect to the 22 high performance related incidents identified in section4, have been identified.

Based in the results from section 5, the following can be said (taking into account the table of allowed combinations in section 9.6.2):

- Certification Specifications:
  - Occupants of high performance CS-23 category aeroplanes have a lower level of safety than those who fly on non-high performance CS-23 aeroplanes. These aeroplanes are not required to be designed to cope with high performance related hazards;
  - For CS-23 high performance aeroplanes the difference in safety level compared to that of CS-25 aeroplanes is greater than for CS-23 non-high performance aeroplanes;
  - For CS-23 aeroplanes in general, the difference in safety level compared to that of CS-25 aeroplanes is increasing due to the continuous increase in the percentage of high performance aeroplanes within CS-23 aeroplanes registered in EASA Member States. At this moment there are already thousands of high performance aeroplanes registered within EASA member States. Currently CRI's are used for airworthiness certification of HPA and as a consequence these CS-23 safety issues are mitigated.

- Flight Crew Licensing:
  - Pilots with a LAPL or PPL licence, and their passengers, who fly with high performance aeroplanes have a lower level of safety than those who fly with non-high performance aeroplanes. Their training is not adapted to cope with high performance related hazards. In the EASA Member States more aeroplane types are type rated than in the United States. For these aeroplane types the FCL safety issues are mitigated.

- Air operations regulations:
  - Occupants in high performance CS-23 category aeroplanes with a MCTOM < 5700 kg and a MPSC < 19 have a lower level of safety than other high performance CS-23 category aeroplanes. Their operation is not required to cope with high performance related hazards (CFIT, mid-air collisions);
  - Occupants in high performance aeroplanes that are non-commercially operated have a lower level of safety than those in commercially operated high performance aeroplanes. Their operation is not required to cope with high performance related hazards (CFIT, mid-air collisions);
  - Occupants of high performance CS-23 category aeroplanes have a lower level of safety than those of non-high performance CS-23 aeroplanes. Their operation is not required to cope with high performance related hazards (hypoxia).

  In practice many high performance aeroplane types have TAWS installed. This means that for these aeroplane types the CFIT hazard is mitigated.

In addition it follows from section 6 that for commercial operations, occupants of single or twin engine jets with MCTOM < 5700 kg and MPSC < 9 have a lower level of safety then other aeroplane classes, because these aeroplanes don't fall within a performance class as defined by part CAT that requires operators to comply with various performance requirements intended to improve safety.

ME Jets are currently put in performance class A by EASA. This means that for these aeroplanes the related hazards are mitigated.

To mitigate the hazards from high performance, and from the situation that single or twin engine jets with MCTOM < 5700 kg and MPSC < don't fall within a performance class, specific LAPL/PPL and/or CS-23 and/or air operations regulations may be needed, following from the following impact assessment.

9.2 Stakeholders affected.

Effected stakeholders in the current situation are:

- Pilots with a LAPL or PPL licence, and their passengers, who fly with high performance aeroplanes have a lower level of safety than those who fly with non-high performance aeroplanes;
- Occupants of high performance CS-23 category aeroplanes have a lower level of safety than those who fly on non-high performance CS-23 aeroplanes;
- Operators of high performance CS-23 category aeroplanes have a lower level of safety than those who operate non-high performance CS-23 aeroplanes;
- Manufacturers of high performance aeroplanes. For obtaining FAA certification, European manufacturers of high performance aeroplanes must first certify their aeroplanes against EASA regulations which involves more costly CRI's than manufacturers from the United States would have to deal with when certifying their aeroplanes under FAA regulations.

9.3 Safety risk assessment

See section 9.6.

9.4 Baseline assessment (pre-RIA scoring)

The following questionnaire provides a quick assessment of the current situation taking into account the objectives of Regulation (EC) No 216/2008 and the feedback loops.

Type of risks and issues under the current regulatory conditions	Estimated significance level				Reasoning
	None	Low 1	Medium 3	High 5	
Safety risks					
1. Have safety risks been identified in section 9.3 that could be mitigated by rule making?				x	See section 9.3.
2. Has a safety recommendation been addressed to the Agency?				x	By BEA (Ref.4)
3. Is the issue linked to a safety action from EASp?	x				
4. Has a related recommendation from Standardisation been issued?	x				
5. Has a future challenge from research, technological advancements, business evolution or new best practices been identified?				x	See beginning of section 9.1
Environmental risks					

Type of risks and issues under the current regulatory conditions	Estimated significance level				Reasoning
	None	Low 1	Medium 3	High 5	
6. Have environmental risks been identified in terms of gaseous emissions (greenhouse gases/local air quality) or noise?	x				
Social risks and issues					
7. Have the EASA rules created social risks or issues, e.g. in terms of limiting free movement of persons, health issues, licencing issues?				x	Health issues: passengers may be exposed to insufficient oxygen or ventilation when flying on CS-23 high performance aeroplanes or on high performance aeroplanes flown by pilots with a LAPL or PPL licence. (note: this is not already counted in the safety analysis). Licensing issues: Passengers on high performance aeroplanes flown by pilots with a LAPL or PPL licence have a lower level of safety than those who fly on non-high performance aeroplanes flown by these pilots (follows from Flight Crew Licensing gap analysis of section 5).
Economic risks including level playing field and proportionality					
8. Have excessive costs of regulatory framework been identified for authorities, industry, license holders, or consumers?	x				
9. Has a competitive disadvantage been identified for certain economic entities (obstacles on the level playing field)?				x	For obtaining FAA certification, European manufacturers of high performance aeroplanes must first certify their aeroplanes against EASA regulations which involves more costly CRI's than manufacturers from the United States would have to deal with when certifying their aeroplanes under FAA regulations.
10. Has an issue for General Aviation (GA)/SMEs been identified contradicting the guidelines in the European GA Strategy?	x				
Regulatory coordination and harmonisation (including legal requirements)					
11. Have implementation problems or regulatory burden been identified?	x				
12. Has a difference or non-compliance with ICAO Standards been identified, or a State Letter been received?	x				
13. Has a need for harmonisation with third countries (e.g. FAA, TCCA) been identified?				x	There are differences between EASA and the FAA and TCCA with respect to regulations related to high performance. Currently there is no harmonisation effort.
Pre-RIA Score					

Type of risks and issues under the current regulatory conditions	Estimated significance level None Low 1 Medium 3 High 5	Reasoning
Significance level	**Significance points**	
A	30	

9.5 Objectives

The general objectives are connected to the objectives laid down in article 2 of Regulation (EC) No. 216/2008, the Basic Regulation. Article 2.1 provides the general and overall objective of EASA. The principal objective is to establish and maintain a high uniform level of civil aviation safety in Europe. In Article 2.2 the additional objectives of EASA are described. Important objectives for this study are:

- To facilitate the free movement of goods, persons and services (2.2b);
- To promote cost-efficiency in the regulatory and certification process and to avoid duplication at national and European level (2.2.c);
- To provide a level playing field for all actors in the internal aviation market (2.2.f).

The specific objective for the options of the rule making proposal is to support business evolution for aircraft manufacturers and operators while ensuring a high level of safety and a consistent approach among the different organisations and Member States.

9.6 Possible measures, policy options and preliminary impacts

In this section, the policy options to achieve the above mentioned objectives are defined.

The study team has preliminary assessed what individual potential measures can be taken to address the safety risks (gaps in the regulations) for each of the incident types that were presented in section 9, and has indicatively identified the key safety, economic (cost), regulatory harmonisation (with the FAA) environment, social (public health & safety, employment) and environment impact of each of these potential measures (section 9.6.1).

Section 9.6.2
Subsequently the allowed combinations of aeroplane category, flight crew licence and type of operation have been determined to identify which combinations of safety risk could occur (section 9.6.1).
It follows that all the identified gaps in CS-23, Air Operations Regulations and Flight Crew Licensing regulations, that correspond with each single high performance thresholds that is exceeded by the performance of a specific aeroplane type, can be applicable at the same time (i.e. to flights with that aeroplane type).

This means that for each single high performance threshold that is exceeded, the most effective measures in CS-23, Air Operations Regulations and Flight Crew Licensing regulations must be identified. To support this, tables have been produced (using the results from section 9.6.1) that show the impact of the proposed measures in accordance with the pre-RIA template (section 9.6.3). It is up to the Agency the weigh the various effects against each other and determine the most effective measures.

9.6.1 Individual regulatory measures and their effect

In this section regulatory measures are proposed per high performance related incident within the airworthiness, air operations and flight crew licensing regulations, based on the gaps in these regulations identified in section 5.1, and their effects are assessed.

Effects

The following effects of the proposed measures have been assessed:

EFFECT ON SAFETY:

- The effect on safety is based on the classification of the effect of an incident, and the extent its occurrence would be reduced as a result of the measure.

EFFECT ON THE ENVIRONMENT:

- The scope of the study is such that the measures have no effect on the environment.

COST FOR STAKEHOLDERS:

- For measures within the Certification Specifications the costs are the costs per aeroplane for newly built aeroplanes (no retrofit);
- For measures within the Air Operations Regulations that request the instalment of certain equipment on the aeroplane, the costs are the costs per aeroplane for newly built aeroplanes (no retrofit). In case retrofit solutions are required, cost will be high as these are very expensive;
- For measures within the Flight Crew Licensing regulations the costs are the costs per pilot.

EFFECT ON PUBLIC HEALTH & SAFETY:

- The ratings for public health & safety are the same as the safety ratings as third party safety risk is directly related to hazardous and catastrophic events in aeroplane operations.

EFFECT ON EMPLOYMENT:

- The ratings for employment are positive for changes in the flight crew licensing regulations, as in this case instructors are needed to train pilots on high performance aeroplanes.

EFFECT ON HARMONISATION WITH THE FAA

Rating of effects

Ratings used to assess the effects are:

0: no effect

1: low effect

2: between low and medium effect
3: medium effect
4: between medium and high effect
5: high effect
For the effect on harmonisation with the FAA, both minus and plus ratings are used to indicate less harmonisation respective more harmonisation.

For calculation of the safety effect rating, the risk reduction and the classification of the effect of the incident must be taken into account.
The probability of occurrence of incidents has not been considered in this analysis.

The following calculation logic has been used:

Effect of proposed measure	Classification of effect of incident	Rating = Effect x Classification (rounded numbers)
Low reduction of risk 1	Minor 0.25	0
Low reduction of risk 1	Major 0.5	1
Low reduction of risk 1	Hazardous 0.75	1
Low reduction of risk 1	Catastrophic 1	1
Medium reduction of risk 3	Minor 0.25	1
Medium reduction of risk 3	Major 0.5	2
Medium reduction of risk 3	Hazardous 0.75	2
Medium reduction of risk 3	Catastrophic 1	3
Large reduction of risk 5	Minor 0.25	1
Large reduction of risk 5	Major 0.5	3
Large reduction of risk 5	Hazardous 0.75	4
Large reduction of risk 5	Catastrophic 1	5

Definition of High Performance

An aeroplane should be defined as a High Performance Aeroplane during Type Certification if any of the parameters mentioned in the table below exceed the threshold value, with an indication of the parameters for which this occurs, in order to identify the applicable proposed regulatory measures (and when regulations have been introduced, the applicable regulations).

High Performance Aeroplane if any of the following:
Presence of speed brake without safety locks that prevent operation in flight regime for which it is not intended
Vmo > 250 kts or Mmo > 0.65
V_{REF} at MLAW > 100 kts
Maximum climb rate > 2000 ft/min
Aeroplane certified for steep approach
Service ceiling > 15,000 ft in relation to pressurisation system failures and warnings
Service ceiling > 25,000 ft in relation to battery duration
Service ceiling > 41,000 ft in relation to rapid decompression at high altitude
Engine power on single engine propeller aeroplanes/weight combination (precise criterion to be developed)
Handling characteristics (aircraft significantly more difficult to handle in case of engine failure than average multi-engine CS-23 aeroplane - precise criterion to be developed)

Certification specifications

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
4a	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => airspace infringement	None	A moving map display that shows airspace boundaries.	**EFFECT ON SAFETY 1** An airspace infringement can result in loss of separation between aircraft. Aircraft with a high speed are more likely to be involved in an airspace infringement. However, for an airspace infringement to become critical other aircraft must be nearby. In the majority of airspace infringements this does not occur. Airspace infringements are therefore considered to cause at least a slight reduction in safety margins and therefore have a minor effect on safety. The proposed change would lead to a large reduction of the probability of the event. **COST PER AEROPLANE 1 to 5** Costs of this type of avionics are estimated to be low to high, dependant on future standardisation of these systems. **EFFECT ON EMPLOYMENT 0** No effect **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **EFFECT ON THE ENVIRONMENT 0** No effect **EFFECT ON PUBLIC HEALTH & SAFETY 1**

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
					Same rating as rating of safety effect.
6	Vmo > 250 kts	Lagging behind events due to high speed => failure to extend landing gear	CS-23 does require a landing gear not extended warning based on wings flaps maximum extended and throttles closed. This does not cover approaches with flaps not fully extended until the moment that the throttles are closed during landing flare. CS-25 requires a warning when a landing is attempted which implies coverage of all approaches.	Require warning system coverage of all allowed flap settings for landing instead of only flaps maximum extended.	**EFFECT ON SAFETY 4** A landing without the landing gear extended is considered hazardous. A landing gear not extended warning system leads to a large reduction of the probability of this happening. **COST PER AEROPLANE 1** The cost of a warning system is estimated to be small. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 3** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 4** Same rating as rating of safety effect.
9	Mmo > 0.65	Exceeding maximum operating altitude and flight near the coffin corner =>	The mitigation in CS-23 is similar to CS-25 which is good, although the requirement to be able to manoeuver at altitude is lacking.	Amend CS-23.251 to include the ability to manoeuvre at altitude, similar to what CS-25.251 requires.	**EFFECT ON SAFETY 3** Near the coffin corner, the margin between the low speed stall speed and high speed stall speed is small. A stall can easily occur. For instance: A turn causes the inner wing to have a lower airspeed, and the

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
		low speed stall and or high speed stall		Note: EASA uses a CRI that requires a 1.3 g manoeuvring margin. This requires only a reduction of the maximum operating altitude.	outer wing to have a higher airspeed. A low speed stall or a high speed stall or both, could occur. Turbulence could cause the airspeed to change suddenly, causing a low speed or high speed stall. Flight near the coffin corner therefore significantly reduces the safety margins and is considered a major effect. The proposed measure of staying away from the coffin corner by flying at an altitude where there is still the ability to manoeuvre (possibly expressed more specifically as a 1.3 manoeuvring margin), is estimated to lead to a large reduction of the probability of occurrence of the incident. **COST PER AEROPLANE 1** The cost for implementing this change is considered small as flying at a lower altitude only requires some extra fuel (which could be compensated for by flying a bit slower). **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 3** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3** Same rating as rating of safety effect.

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
12	Maximum climb rate > 2000 ft/min	Level bust due to high climb rate	No mitigation in CS-23 (also no mitigation in CS-25)	New regulation that requires avionics which allows the setting of a target altitude/flight level and provides an altitude/flight level alert if this altitude is exceeded	**EFFECT ON SAFETY 1** A Level Bust can result in loss of separation between aircraft. Aircraft with a high climb rate are more likely to be involved in a level bust. However, for a level bust to become critical a very large deviation from the assigned altitude is required and other aircraft must be nearby. In the vast majority of level busts this does not occur. Level busts are therefore considered to cause at least a slight reduction in safety margins and therefore have a minor effect on safety. The proposed change would lead to a large reduction of the probability of level busts. **COST PER AEROPLANE 1** Costs are estimated to be small if the aeroplane is designed with a modern avionics suite. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1** Same rating as rating of safety effect.

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
13	Maximum climb rate > 2000 ft/min	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia	Inadequate mitigation in CS-23 CS 23.365 Pressurised compartment loads less stringent than CS 25.365 Pressurised compartment loads CS 23.841 does not require that loss of pressure warning will be given without delay, as in CS 25.841 CS 23.841 does not require that aural or visual signal (in addition to cabin altitude indication means) is given, as in CS 25.841	The provision of a loss of pressure warning without delay and an aural warning, as required by CS 25.841 is considered essential to mitigate this incident, as without this mitigation this incident could be fatal.	**EFFECT ON SAFETY 5** During a hypoxia event pilot alertness, situational awareness, and vision are reduced significantly. During such an event the pilot cannot be relied upon to perform his/her tasks accurately or completely (losing consciousness in the end). Hence a hazardous or even catastrophic condition can occur. The proposed changes would lead to a large reduction of hypoxia events. **COST PER AEROPLANE 1 to 3** The costs for implementing the changes are estimated to be low to medium based on the availability of a low-cost aural warning for cabin altitude exceedance. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.
14	Aeroplane certified for steep	Hard landing due to steep approach	No mitigation in CS-23 CS-25 Appendix Q, (SAL) 25.3(a)(5) requires if the landing procedure	Take over CS-25 Appendix Q, (SAL) 25.3(a)(5)	**EFFECT ON SAFETY 1 to 2** A hard landing can result into damage to the aircraft (typically damage to the landing gear). A hard landing can also result into

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
	approach		(speed, configuration, etc.) differs significantly from normal operation, or if the screen height is greater than 50 ft.) that the landings may not require exceptional piloting skill or alertness.		a high speed runway excursion in which the aircraft departs the side of the runway. Depending on the condition of the runway strip, the nose and/or main landing gear could collapse. This is more likely to occur on a wet runway strip than on a dry one as the landing wheels tend to dig into the wet grass surface. A hard landing would typically have a minor to major impact. The proposed changes would lead to a medium reduction of the probability of a hard landing. **COST PER AEROPLANE 1** Costs for implementing these changes are estimated to be low. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1 to 2** Same rating as rating of safety effect.
15	Aeroplane certified for steep approach	Undershoot due to steep approach	No mitigation in CS-23 CS-25 Appendix Q, (SAL) 25.3(a)(5) requires if the landing procedure (speed, configuration, etc.) differs significantly from normal operation,	Take over CS-25 Appendix Q, (SAL) 25.3(a)(5)	**EFFECT ON SAFETY 1** An undershoot is an event in which the aircraft lands short of the threshold (often within the runway end safety area). During an undershoot the pilot flares the aircraft as during a normal landing on the runway. If the undershoot occurs outside the runway end

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
			or if the screen height is greater than 50 ft.) that the landings may not require exceptional piloting skill or alertness		safety area there is possibility of some minor damage. Any objects that might be near the runway should normally be frangible and therefore should have little impact on the aircraft. An undershoot would not significantly reduce safety, and would therefore only has a minor impact. The proposed changes would lead to a medium reduction of the probability of undershoots. **COST PER AEROPLANE 1** Costs for implementing the proposed changes are estimated to be small. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1** Same rating as rating of safety effect.
16	Service ceiling > 15,000 ft	Failure to timely detect failure in cabin pressurisation system or	Inadequate mitigation in CS-23 CS 23.365 Pressurised compartment loads less stringent than CS 25.365 Pressurised compartment loads CS 23.841 does not require that loss	The provision of a loss of pressure warning without delay and an aural warning, as required by CS 25.841 is considered essential to	**EFFECT ON SAFETY 5** During a hypoxia event pilot alertness, situational awareness, and vision is reduced significantly. During such an event the pilot cannot be relied upon to perform his/her tasks accurately or completely (losing consciousness in the end). Hence a

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
		supplemental oxygen system due to high operating altitude => hypoxia	of pressure warning will be given without delay, as in CS 25.841 CS 23.841 does not require that aural or visual signal (in addition to cabin altitude indication means) is given, as in CS 25.841 or FAR §23.841.	mitigate this incident, as without this mitigation the incident is most likely fatal.	hazardous or even catastrophic condition can occur. The proposed changes would lead to a large reduction of hypoxia events. **EFFECT ON EMPLOYMENT 0** No effect. **COST PER AEROPLANE 1 to 3** The costs for implementing the changes are estimated to be low to medium based on the availability of a low-cost aural warning for cabin altitude exceedance. **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.
17	Service ceiling > 25,000 ft or Service ceiling > 41,000 ft	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at	Inadequate mitigation For operations above 25,000 ft the requirement from CS 25.1447 that oxygen dispensing units for the flight crew must be within easy reach and can be placed into position within 5 seconds is missing in CS-23.1447: For operations above 25,000 ft, CS-	**Option A:** Do not rely on Guidance Material and formalise the 5 seconds in the regulation as without this mitigation the incident can be fatal, especially in small aeroplanes where the cabin	**EFFECT ON SAFETY 5** Failure to put on an oxygen mask could lead to hypoxia or even losing consciousness. During such an event the pilot cannot be relied upon to perform his/her tasks accurately or completely (when losing consciousness). Hence a hazardous or even catastrophic condition can occur. The proposed changes would lead to a large reduction of

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
		high altitude => hypoxia	23.1447 allows a quick donning mask connected to an oxygen supply terminal that is immediately available (although without requiring they are within easy reach and can be mounted within 5 seconds), or oxygen dispensing units that automatically present themselves GM1 NCC.IDE.A.195(c)(2) Supplemental oxygen – pressurised aeroplanes and GM1 CAT.IDE.A.235(b)(1) Supplemental oxygen pressurised aeroplanes defines a quick donning mask as a mask that can be placed into position within 5 seconds FAR §23.1447 Equipment standards for oxygen dispensing units has requirement for: A quick donning mask (supplying oxygen on demand) that is immediately available and can be placed into position within 5 seconds in aeroplanes with operations above 41,000 ft CS-23.1447 allows a quick donning mask connected to an oxygen supply terminal that is immediately	pressure drops quicker than in large aeroplanes.	hypoxia events. **Option A** **COST PER AEROPLANE** The costs for implementing the changes are estimated to be medium for the quick donning masks, limits in cabin altitude during decompression and the continuous flow oxygen systems. **Option B** **COST PER AEROPLANE 1** The costs for implementing the changes are estimated to be small for the autopilot mode. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA** 5 **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
			available, or oxygen dispensing units that automatically present themselves. Note: below 41,000 ft CS-23 and part 23 allows a quick donning mask connected to an oxygen supply terminal that is immediately available, or oxygen dispensing units that automatically present themselves		
			FAR §23.841 Pressurized cabins has limits in cabin altitude during decompressions that are not in CS-23 for operation above 41,000 ft and 45,000 ft.	Take cabin altitude limits over from FAR §23.841.	
			FAR §23.1443 Minimum mass flow of supplemental oxygen requires continuous flow oxygen systems for passengers in airplanes with operations above 41,000 feet MSL. CS-23.1443 allows a choice between continuous flow oxygen systems and first-aid oxygen equipment. (note: below 41,000 ft both CS-23 and part 23 allow a choice between continuous flow oxygen systems and first-aid oxygen equipment for	Bring CS-23.1443 in line with FAR §23.1443 which implies to only allow continuous flow oxygen systems for passengers above 41,000 ft.	

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
			passengers) For flight above 41,000 feet MSL, §23.571 (d) Metallic pressurized cabin structures requires a damage tolerance evaluation of the fuselage pressure boundary per § 23.573(b) must be conducted for cabin rupture as a discrete case. CS-23.571 does not require this.	OR **Option B:** Provide an autopilot mode that brings the aeroplane in an emergency descent in case of loss of cabin pressure.	
18	Service ceiling > 25,000 ft	Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing is exhausted, in case of loss of primary electrical	Inadequate mitigation in CS-23 The battery is required by CS-23.1353 to provide 30 minutes of electrical power which is judged to be short when the failure of the primary electrical power generation system occurs above 25,000 ft.	Require 60 minutes for aeroplanes with a maximum altitude over 25,000 ft, similar to what FAR §23.1353 requires	**EFFECT ON SAFETY 1 to 3** When losing the primary electrical power and after the backup battery is empty a forced landing will have to be made. Depending on the surroundings (e.g. trees, buildings, powerlines, flat open area, mountains etc.) of the location, the forced landing can have several outcomes varying from minor to catastrophic. Extending the battery power to 60 minutes as proposed will give the pilot more opportunities to e.g. return to the nearest airport or find a suitable location for a forced landing. The proposed

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
		power generating system at high altitude (tbd ft)			changes would lead to a medium reduction of these events. **COST PER AEROPLANE 1** Costs associated with the proposed change are estimated to be low. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1 to 3** Same rating as rating of safety effect.
19	Service ceiling > 41,000 ft	Reduced flight crew performance due to poor ventilation at high altitude	FAR §23.573 Ventilation has ventilation requirements for operations above 41,000 feet MSL that are not in CS-23.	Take over the FAR §23.573 ventilation requirements for operations above 41,000 feet MSL	**EFFECT ON SAFETY 1** Reduced flight crew performance is assessed to have a minor effect during cruise flight. Providing adequate ventilation would lead to a large reduction of the probability of this happening. **COST PER AEROPLANE 1 to 3** Costs associated with the proposed change are estimated to be low to medium. **EFFECT ON EMPLOYMENT 0** No effect.

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
					EFFECT ON REGULATORY HARMONISATION WITH FAA 5 **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1** Same rating as rating of safety effect.
20	Engine power on single engine propeller aeroplanes, weight (precise criterion to be developed)	Loss of control after applying power at low speeds near the stall (e.g. during approach or go-around) on single engine propeller aeroplanes with high power to weight ratio	CS-23 contains adequate mitigation: CS-23.143 requires the aeroplane to be safely controllable and manoeuvrable during all flight phases including go-around and landing (power on and power-off). It must be possible to make a smooth transition to another. However CS-23.143 is subjective to the judgement of a test pilot. Specific flight handling criteria are not provided. This has led to type rating inconsistencies. For example the Socata TBM700, which is quite unforgiving, does not require a type rating, whereas the Pilatus PC-12 which is easier to fly, does require a type rating. FAR §23.691 artificial stall barrier system allows the aeroplane to use	**Option A:** Provide specific flight handling criteria for flight at low speeds near the stall with high engine power. OR **Option B:** Allow the aeroplane to use an artificial stall barrier system to comply with CS-23.201 wings level stall, similar to FAR §23.691 artificial stall barrier system	**EFFECT ON SAFETY 5** A loss of control at low speeds during approach or go-around can result into a crash very quickly as there is little time to recover if possible at all. This would result in fatalities, usually with the loss of the aircraft. This would be a catastrophic outcome. The proposed changes would lead to a large reduction of the probability that a pilot would enter such a loss of control condition. **Option A:** **COST PER AEROPLANE 3** The costs of the stall barrier are estimated to be medium. **Option B:** **COST PER AEROPLANE unknown** The cost of improved handling qualities cannot be quantified as this is an integral part of the aeroplane design. **EFFECT ON EMPLOYMENT 0**

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
			an artificial stall barrier system to comply with CS-23.201 wings level stall.		No effect. **Option A:** **EFFECT ON REGULATORY HARMONISATION WITH FAA minus 5** **Option B:** **EFFECT ON REGULATORY HARMONISATION WITH FAA 5.** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.
21	Significantly more difficult to handle in case of engine failure than average multi-engine CS-23 aeroplane (precise criterion to be	Loss of control after engine failure on multi-engine aeroplane	The difference between CS-23 and CS-25 is small: CS-23 requires the minimum V1 to be either 1.05 Vmca or Vmcg. CS-25 requires the minimum V1 to be Vmcg. In practice there is only a difference if 1.05 Vmca is smaller than Vmcg which will is not very likely. CS-23 does not require a Vr. This does not seem to lead to incidents in practice. CS-23 does not require the ability to perform a turn that is free of stall warnings @ V2. It is assessed that this is sufficiently covered by the minimum	None are necessary.	Not applicable.

No.	Threshold value	High performance related incident type	Gap in CS-23 relative to CS-25 or part 23	Proposed regulatory measures for CS-23	Main effect of measures
	developed)		requirements imposed on V2 and Vmc. Summarising: CS-23 adequately covers this incident.		

Operations regulations

No.	Threshold value	Incident type	Gaps in operations regulations	Possible regulatory measures for operations regulations	Main effect of measures
4b	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed or high climb rate => loss of separation	For commercial operations ACAS is only required for operations with aeroplanes with a MCTOM greater than 5700 kg or a MPSC of more than 19. For high performance aeroplanes with a MCTOM of no more than 5700 kg and a MPSC of no more than 19 that are commercially operated, there is no mitigation (ACAS is not required). For non-commercially operated high performance aeroplanes ACAS is not required. As high performance aeroplanes operate in a larger part of airspace, this reduces the safety level of commercially operated aeroplanes that are ACAS equipped.	**Option A:** Require ACAS on aircraft with a Vmo> 250 kts or a climb rate higher than 2000 ft/min for commercial operations and non-commercial operations. OR **Option B:** Require ACAS on aircraft with a Vmo > 250 kts or a climb rate higher than 2000 ft/min for commercial operations As ACAS is a large and expensive aircraft system. For non-commercially operated aircraft with a Vmo > 250 kts or a climb rate higher than 2000 ft/min, other means could be more appropriate to cope with lack of traffic awareness, such as Traffic Awareness System (TAS), Traffic Information System (TIS) which uploads traffic information from ATC,	Loss of separation is a Hazardous event and could lead to a mid-air collision. A simple system like a Traffic Advisory System (TAS) monitors the airspace around the aircraft and indicates where to look for nearby transponder-equipped aircraft. This is estimated to lead to a small reduction of mid-air collisions. More advanced models calculate distance and direction of nearby aircraft. These systems display relative altitude and whether the target aircraft is climbing or descending. Should the aircraft be determined to be a threat, this information is used to display a “Traffic Advisory” (TA). This is estimated to lead to a small to medium reduction of the risk of mid-air collisions. The most effective systems are those that can generate a Resolution Advisory (RA). This last system can reduce the probability of a mid-air collision by a factor from 4 to 50 depending on the correct pilot reaction to the ACAS RA. This is estimated to lead to a large reduction of the risk of mid-air collisions. The costs are low for the simple systems. The costs are high for the ACAS systems. **Option A:** **EFFECT ON SAFETY 4** **Option B:** **EFFECT ON SAFETY 4** for commercial operators;

No.	Threshold value	Incident type	Gaps in operations regulations	Possible regulatory measures for operations regulations	Main effect of measures
				and FLARM.	**EFFECT ON SAFETY 1** for non-commercial operators. **Option A:** **COST PER AEROPLANE 5** **Option B:** **COST PER AEROPLANE 5** for commercial operators; **COST PER AEROPLANE 1** for non-commercial operators. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** There is no need to harmonise as it is assumed that operators that fall under EU operating regulations will not operate their CS-23 aeroplanes outside Europe. **EFFECT ON THE ENVIRONMENT 0** No effect. **Option A:** **EFFECT ON PUBLIC HEALTH & SAFETY 4** **Option B:** **EFFECT ON PUBLIC HEALTH & SAFETY 4** for commercial operators; **EFFECT ON PUBLIC HEALTH & SAFETY 1** for non-commercial operators.

No.	Threshold value	Incident type	Gaps in operations regulations	Possible regulatory measures for operations regulations	Main effect of measures
5	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed=> improper navigation in the vicinity of terrain (CFIT)	**Option A:** TAWS was developed as a final barrier against CFIT. TAWS is only required for commercial operations with aeroplanes with a MCTOM greater than 5700 kg or a MPSC of more than 9 (CS-23 Commuter and CS-25). For high performance aeroplanes with a MCTOM of no more than 5700 kg and a MPSC of no more than 9 (CS-23 Normal), TAWS is not required.	There is a Notice of Proposed Amendment (NPA 2015-21) on requiring TAWS on turbine-powered aeroplanes under 5 700 kg MCTOM able to carry six to nine passengers. It would be desirable to require TAWS on all aeroplanes with a Vmo > 250 kts for commercial operations and non-commercial operations.	**Option A:** **EFFECT ON SAFETY 5** CFIT events normally result in fatalities, usually with the loss of the aircraft. This would be a catastrophic outcome. The proposed changes for would reduce the probability of a CFIT event significantly. Typically a TAWS system can reduce the CFIT probability with some 85% which is large. The remainder is the result of pilots not adhering to the TAWS warnings. **COST PER AEROPLANE 1** Costs of TAWS system is estimated to be low based on current market prices (Class B TAWS – around 15,000- Euro). **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** There is no need to harmonise as it is assumed that operators that fall under EU operating regulations will not operate their CS-23 aeroplanes outside Europe. **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.

No.	Threshold value	Incident type	Gaps in operations regulations	Possible regulatory measures for operations regulations	Main effect of measures
			Option B: CS-23 aeroplanes when flown by a single pilot lack the situational awareness of two-pilot CS-25 aeroplanes with a consequent higher risk of CFIT, especially in case of high speed aeroplanes.	It is judged that barriers such as synthetic vision and showing terrain on a moving map display would be effective here because they come into effect earlier than a final barrier such as TAWS. These are currently not required by the regulations. However this would require high integrity systems, contrary to current practice where the terrain database is of insufficient integrity to take credit for CFIT prevention by these systems.	**Option B:** **EFFECT ON SAFETY 5** CFIT events normally result in fatalities, usually with the loss of the aircraft. This would be a catastrophic outcome. The proposed changes ((synthetic vision or a moving map display) would lead to a large reduction of the probability of a CFIT event in CS-23 aeroplanes flown by a single pilot. **COST PER AEROPLANE 1-5** Costs of this type of avionics (synthetic vision or a moving map display) are estimated to be low to high, dependant on future standardisation of these systems. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** There is no need to harmonise as it is assumed that operators that fall under EU operating regulations will not operate their CS-23 aeroplanes outside Europe. **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.
17	Service ceiling >	Failure to timely put on oxygen	There is no regulation that requires a single pilot in the cockpit to wear an	Take over FAR §23.211 supplemental oxygen	**EFFECT ON SAFETY 5** Failure to put on an oxygen mask could lead to hypoxia or even

No.	Threshold value	Incident type	Gaps in operations regulations	Possible regulatory measures for operations regulations	Main effect of measures
	15,000 ft	mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia	oxygen mask in certain high altitude conditions, as in FAR §23.211 supplemental oxygen. Note: in small aeroplanes the effect is stronger as the cabin pressure rapidly decreases in case of a hole in the fuselage. Also these aeroplanes are often flown by a single pilot.	regulation that that requires a single pilot in the cockpit to wear an oxygen mask in certain high altitude conditions.	losing consciousness. During such an event the pilot cannot be relied upon to perform his/her tasks accurately or completely (when losing consciousness). Hence a hazardous or even catastrophic condition can occur. The proposed changes will result in the fact that hypoxia events are basically prevented, which is a large reduction. **COST PER AEROPLANE 0** There are no costs for implementing the changes. **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA 5** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.
22	Not applicable	Runway excursion due to insufficient runway length margins used for take-off and landing. CFIT due to insufficient obstacle or terrain clearance margins	Single and twin engine jets with MCTOM < 5700 kg and MPSC < 9 don't fall within a performance class as defined by part CAT that requires commercial operators to take into account runway length and obstacle clearance margins.	Put twin engine jets with MCTOM < 5700 kg and MPSC < 9 in Performance Class A. This matches best with the performance of other aeroplanes categories within Class A. The only single engine jet	**EFFECT ON SAFETY 5** A runway excursion is rated as Hazardous. A CFIT event is rated as Catastrophic. The proposed changes will lead to a large reduction in the probability of these events. **COST PER AEROPLANE 0** There are no costs for implementing the changes (apart from

No.	Threshold value	Incident type	Gaps in operations regulations	Possible regulatory measures for operations regulations	Main effect of measures
		used for climb and en-route flight phases.		with MCTOM < 5700 kg and MPSC < 9aeroplane on the market today is the Cirrus Vision Jet which has performance similar to aeroplane types in Class B. Therefore the most fitting performance class for the Cirrus Vision Jet is Class B. Once a representative set of single engine jet aeroplane types become available, depending on their performance it can be reconsidered if an adapted class A would be appropriate. An adapted class A meaning class A excluding the engine failure accountability and excluding requirements to take loss of runway length due to alignment into account which is judged to be unnecessary for small aeroplanes. Performance classes need to be reassessed after the reorganisation of CS-23.	performing the performance calculations prior to a flight). **EFFECT ON EMPLOYMENT 0** No effect. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** There is no need to harmonise as it is assumed that operators that fall under EU operating regulations will not operate their CS-23 aeroplanes outside Europe. **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 5** Same rating as rating of safety effect.

Flight Crew License regulations

Note: The FAA Safety Team (FAAST) has proposed ‘Single-Pilot Crew Resource Management’ training for single-pilot operations. Part of the proposed training is procedural training. Although a specific training program has not been defined yet, the idea of ‘Single-Pilot Crew Resource Management ’could also be considered in Europe as a way to mitigate incidents 1,2,3,4a,4b,5,6,7,12,13, 16, 17.

This as an alternative to ‘Training for Type rating or HPA rating or providing training as part of PPL training’ as mentioned in the tables below.

With regard to regulatory harmonisation: it is the responsibility of the FAA to grand privileges based on an EASA Flight Crew License. It is assumed that the proposed regulatory measures would not change this current practice.

No.	Threshold value	Related incidents	LAPL mitigation level	Proposed regulatory measures	Main effect of measures
13	Maximum climb rate > 2000 ft/min	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia	No Mitigation. Hypoxia training not required.	Training for Type rating or HPA rating or provide training as part of PPL training. Specifically Hypoxia-and procedural training.	**EFFECT ON SAFETY 3, with experience 5** Hypoxia may lead to loss of control or fuel starvation when on autopilot. In almost all cases the effect will be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect.

No.	Threshold value	Related incidents	LAPL mitigation level	Proposed regulatory measures	Main effect of measures
					EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5 Same rating as rating of safety effect.
16	Service ceiling > 15,000 ft	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system at high altitude => hypoxia	No Mitigation. Hypoxia training not required	Training for Type rating or HPA rating or provide training as part of PPL training. Specifically Hypoxia-and procedural training	**EFFECT ON SAFETY 3, with experience 5** Hypoxia may lead to loss of control or fuel starvation when on autopilot. In almost all cases the effect will be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
17	Service ceiling > 15,000 ft	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia	No Mitigation. Emergency descent procedure training not required	Training for Type rating or HPA rating or provide training as part of PPL training. Specifically Hypoxia-and procedural training	**EFFECT ON SAFETY 3, with experience 5** Hypoxia may lead to loss of control or fuel starvation when on autopilot. In almost all cases the effect will be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high.

No.	Threshold value	Related incidents	LAPL mitigation level	Proposed regulatory measures	Main effect of measures
					EFFECT ON EMPLOYMENT 1 Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
1	Presence of speed brake without safety locks that prevent operation in flight regime for which it is not intended	Speed brake extended in flight regime where this is not permitted => stall	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston. If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically procedural training and recovery from stall.	**EFFECT ON SAFETY 3, with experience 5** Especially the extension of a speed brake at low speed may result in a stall. As low speed is mainly during take-off and landing, and thus at low altitude, recovery may not be possible. The effect is rated Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
2	Vmo > 250	Lagging	Mitigation if MPL or MCC		Mitigation due	Training for Type	**EFFECT ON SAFETY 2, with experience 3**

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
	kts or Mmo > 0.65	behind events due to high speed => late communication to other crew members.	training FCL 720A		to training on the use of instrumentation.	rating or HPA rating or provide training as part of PPL training. Specifically procedural training.	Late communication to other crew members may lead to disruption of Standard Operating Procedures. The effect is rated as Major. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 3** Same rating as rating of safety effect.
3	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => late	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine		Mitigation due to training of flying under ATC control.	Training for Type rating or HPA rating or provide training as part	**EFFECT ON SAFETY 2, with experience 3** Late reporting to ATC may lead to loss of separation. The effect is rated as Major.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
		reporting to ATC.	piston. If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			of PPL training. Specifically procedural training and use of avionics.	Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 3** Same rating as rating of safety effect.
4a	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => airspace infringement				Training for Type rating or HPA rating or provide training as part of PPL training. Specifically procedural training	**EFFECT ON SAFETY 1, with experience 1** An airspace infringement can result in loss of separation between aircraft. Aircraft with a high speed are more likely to be involved in an airspace infringement. However, for an airspace infringement to become critical other aircraft must be nearby. In the majority of airspace infringements this does not occur. Airspace infringements are therefore

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
							considered to cause at least a slight reduction in safety margins and therefore have a minor effect on safety. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1, with experience 1** Same rating as rating of safety effect.
4b	Vmo > 250 kts or Mmo > 0.65 Or	Lagging behind events due to high speed or high				Training for Type rating or HPA rating or provide training as part	**EFFECT ON SAFETY 2, with experience 4** Loss of separation is a Hazardous event and could lead to a mid-air collision.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
	Maximum climb rate > 2000 ft/min	climb rate => loss of separation				of PPL training. Specifically procedural training	Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 4** Same rating as rating of safety effect.
5	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => improper navigation in the vicinity of terrain (CFIT).	No mitigation. TAWS not required.		Mitigation due to training of flying under ATC control and usage of maps.	Training for Type rating, HPA rating or Instrument rating or provide training as part of PPL training. Specifically procedural	**EFFECT ON SAFETY 3, with experience 5** The result of lagging behind the facts may result in late or no procedure execution, hurried behaviour. The result may be that steps in procedures are not executed. Disorientation in time and space is likely, leading to loss of control and/or CFIT. The possible effect is rated Catastrophic. Medium reduction of risk with required rating. Large

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
						training and use of avionics (TAWS).	reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
6	Vmo > 250 kts	Lagging behind events due to high speed => failure to extend landing gear.				Training for Type rating or HPA rating or provide training as part of PPL training. Specifically procedural training.	**EFFECT ON SAFETY 2, with experience 4** A landing without the landing gear extended is considered hazardous. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
							EFFECT ON EMPLOYMENT 1 Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 4** Same rating as rating of safety effect.
7	Vmo > 250 kts or Mmo > 0.65	Fuel starvation (poor flight planning) due to high variation of fuel consumption with altitude and speed.	Standard Pilot knowledge although awareness of great variation of fuel consumption with speed and altitude could be lacking.			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically procedural training.	**EFFECT ON SAFETY 2, with experience 4** Fuel starvation results in a forced landing. A forced landing not always Catastrophic. The result is therefore rated as Hazardous. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 1** Costs are estimated to be low. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
							EFFECT ON REGULATORY HARMONISATION WITH FAA 0 **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 4** Same rating as rating of safety effect.
8	Mmo > 0.65	Exceeding M_{MO} and high speed buffet => high speed stall	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston. If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically recovery from stall.	**EFFECT ON SAFETY 2, with experience 3** Recovery from a high speed stall at maximum operating altitude may be recoverable. The effect is rated as Major. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0**

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
							EFFECT ON THE ENVIRONMENT 0 No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 3** Same rating as rating of safety effect.
9	Mmo > 0.65	Exceeding maximum operating altitude and flight near the coffin corner => low speed stall and/or high speed stall.	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston. If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically recovery from stall.	**EFFECT ON SAFETY 2, with experience 4** A stall near the coffin corner is Hazardous. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 4**

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
							Same rating as rating of safety effect.
10	V_{REF} at MLAW > 100 kts	Hard landing due to high approach speed	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston. If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically touch and go training.	**EFFECT ON SAFETY 2, with experience 3** A hard landing may result in damage to the landing gear and consequent runway excursion. In most cases, though, the landing gear may only be damaged and runway excursion may not occur. The effect is considered Major. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 3** Same rating as rating of safety effect.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
11	V_{REF} at MLAW > 100 kts	Long landing due to high approach speed	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston. If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically touch and go training.	**EFFECT ON SAFETY 2, with experience 4** The effect is rated as Hazardous. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 4** Same rating as rating of safety effect.
12	Maximum climb rate > 2000 ft/min	Level bust due to high climb rate.	No mitigation.		Mitigation due to training of procedural flying.	Training for Type rating, HPA rating or Instrument rating or provide	**EFFECT ON SAFETY 1, with experience 1** A Level Bust can result in loss of separation between aircraft. Aircraft with a high climb rate are more likely to be involved in a level bust. However, for a level bust to become critical a very large

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
						training as part of PPL training. Specifically procedural training.	deviation from the assigned altitude is required and other aircraft must be nearby. In the vast majority of level busts this does not occur. Level busts are therefore considered to cause at least a slight reduction in safety margins and therefore have a minor effect on safety. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1, with experience 1** Same rating as rating of safety effect.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
13	Maximum climb rate > 2000 ft/min	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia.	No Mitigation. Hypoxia training not required.			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically Hypoxia-and procedural training.	**EFFECT ON SAFETY 3, with experience 5** Hypoxia may lead to loss of control or fuel starvation when on autopilot. In almost all cases the effect will be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
14	Aeroplane certified for steep approach	Hard landing due to steep approach	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston.			Training for Type rating or HPA rating or provide training as part of PPL training.	**EFFECT ON SAFETY 2, with experience 3** A hard landing may result in damage to the landing gear and consequent runway excursion. In most cases, though, the landing gear may only be damaged and runway excursion may not occur. The

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
			If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			Specifically touch and go training.	effect is considered Major. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 2, with experience 3** Same rating as rating of safety effect.
15	Aeroplane certified for steep approach	Undershoot due to steep approach	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston.			Training for Type rating or HPA rating or provide training as part of PPL training. Specifically	**EFFECT ON SAFETY 1, with experience 1** An undershoot is an event in which the aircraft lands short of the threshold (often within the runway end safety area). During an undershoot the pilot flares the aircraft as during a normal landing on the runway. If the undershoot occurs outside the runway

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
			If multi pilot aircraft then MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			touch and go training	end safety area there is possibility of some minor damage. Any objects that might be near the runway should normally be frangible and therefore should have little impact on the aircraft. An undershoot would not significantly reduce safety, and would therefore only has a minor impact. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 1, with experience 1** Same rating as rating of safety effect.
16	Service	Failure to	No mitigation. Hypoxia			Training for Type	**EFFECT ON SAFETY 3, with experience 5**

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
	ceiling > 15,000 ft	timely detect failure in cabin pressurisation system or supplemental oxygen system at high altitude => hypoxia.	training not required.			rating or HPA rating or provide training as part of PPL training. Specifically Hypoxia-and procedural training.	Hypoxia may lead to loss of control or fuel starvation when on autopilot. In almost all cases the effect will be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
17	Service ceiling > 15,000 ft	Failure to timely put on oxygen mask and/or perform	No mitigation. Procedure training not required.			Training for Type rating or HPA rating or provide training as part	**EFFECT ON SAFETY 3, with experience 5** Hypoxia may lead to loss of control or fuel starvation when on autopilot. In almost all cases the effect will be Catastrophic.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
		emergency descent after rapid decompression at high altitude => hypoxia.				of PPL training. Specifically Hypoxia-and procedural training.	Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). Training cost low. **COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
20	Engine power on single engine propeller aeroplanes, weight	Loss of control after applying power at low speeds near the stall (e.g. during approach or	Mitigation if type identified as single pilot single engine HPA or single pilot multi engine HPA or multi engine piston. If multi pilot aircraft then		Mitigation due to training of manoeuvres under instrument conditions.	Training for Type rating or HPA rating or provide training as part of PPL training. Specifically recovery from	**EFFECT ON SAFETY 3, with experience 5** Loss of control near the ground will normally be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours).

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
	(precise criterion to be developed)	go-around) on single engine propeller aeroplanes with high power to weight ratio.	MCC training and/or type rating required which provide mitigation. // Regulation 1178-2011 FCL 710-720-725 - Appendix 8 and 9			stall.	**COST PER PILOT 5** Costs are estimated to be high. **EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.
21	Significantly more difficult to handle in case of engine failure than average multi-engine CS-23	Loss of control after engine failure on the ground or in flight on multi-engine aeroplane	N.A.	Mitigation by MEP required training FCL.725.A		Training for Type rating or HPA rating or provide training as part of PPL training. Specifically recovery from stall.	**EFFECT ON SAFETY 3, with experience 5** Loss of control near the ground will normally be Catastrophic. Medium reduction of risk with required rating. Large reduction of risk with required rating and experience (PIC hours). **COST PER PILOT 5** Costs are estimated to be high.

No.	Threshold value	Related incidents	PPL without type rating: mitigation level	Multi engine piston class rating FCL 725: mitigation level	PPL with instrument rating FCL 600-825: mitigation level	Proposed regulatory measures	Main effect of measures
	aeroplane (precise criterion to be developed)						**EFFECT ON EMPLOYMENT 1** Instructors are needed to train pilots on high performance aeroplanes. **EFFECT ON REGULATORY HARMONISATION WITH FAA 0** **EFFECT ON THE ENVIRONMENT 0** No effect. **EFFECT ON PUBLIC HEALTH & SAFETY 3, with experience 5** Same rating as rating of safety effect.

9.6.2 *Combined regulatory options*

The table below shows the allowed combinations of aeroplane category, flight crew licence and type of operation. The red, green and blue fields shows the areas where there are gaps in the regulations for high performance aeroplanes as identified in section 5.

Licence / rating: **Privileges:**	**LAPL**	**PPL without type rating**	**PPL without type rating, with MEP class rating**	**PPL with type rating**	**CPL**	**MPL**	**ATPL**
Aircraft weight	Less than 2000 kg	Less than 5700 kg	Less than 5700 kg	More than 5700 kg	All weights	All Weights	All Weights
Number of pax	Less than 2 pax/4 total	Less than 4 pax/4 total	Less than 4 pax/4 total	Less than 4 pax/4 total	All Pax	All Pax	All Pax
Type and number of engine(s)	Single Piston	Single Piston	Multi Piston	Any	Any	Any	Any
CS category	CS-23 Normal	CS-23 Normal	CS-23 Normal CS-23 Commuter	CS-23 Normal CS-23 Commuter CS-25	CS-23 Normal CS-23 Commuter CS-25	CS-23 Normal CS-23 Commuter CS-25	CS-23 Normal CS-23 Commuter CS-25
Type of operation	part NCO part NCC	part NCO part NCC	part NCO part NCC	part NCO part NCC	part NCO part NCC Part CAT	part NCO part NCC Part CAT	part NCO part NCC Part CAT

From this table it follows that:

- Gaps in CS-23 regulations are always applicable for CS-23 high performance aeroplanes.
- Gaps in LAPL or PPL regulations are applicable if such a pilot flies a CS-23 high-performance aeroplane.
- Some gaps in air operations regulations are always applicable for operation with CS-23 high performance aeroplanes, and some gaps are applicable if the CS-23 high performance aeroplane has a MCTOM < 5700 kg and a MPSC < 19 or is non-commercially operated.

The precise gaps follow from the high performance thresholds that are exceed by the performance of the specific aeroplane.

9.6.3 *Preliminary impacts and recommended action*

Effectively the allowed combinations from section 9.6.2 imply that all the identified gaps in CS-23, Air Operations Regulations and Flight Crew Licensing regulations, that correspond with each single high performance thresholds that is exceeded by the performance of a specific aeroplane type, can be applicable at the same time (i.e. to flights with that aeroplane type).

This means that for each single high performance threshold that is exceeded, the most effective measures in CS-23, Air Operations Regulations and Flight Crew Licensing regulations must be identified. To support this, the following tables have been produced, which show the impact of the proposed measures in accordance with the pre-RIA template (using the results from section 9.6.1). It is up to the Agency the weigh the various effects against each other and determine the most effective measures.

For each regulatory domain (Certification Specifications, Air Operations Regulations and Flight Crew Licensing) average values of the impact of all the proposed measures have been calculated to give an indication where the greatest positive and negative effects would occur if all measures would be implemented.

CS-23

No.	Threshold value	Incident type	Possible regulatory measures for CS-23	Effect on safety	Cost per aeroplane	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
4a	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => airspace infringement	Moving map display	**1**	**1 to 5**	**minus 5**	**0**	**0**	**1**
6	Vmo > 250 kts	Lagging behind events due to high speed => failure to extend landing gear	Landing gear not extended warning system for all flap settings for landing.	**4**	**1**	**minus 3**	**0**	**0**	**4**
9	Mmo > 0.65	Exceeding maximum operating altitude and flight near the coffin corner => low speed stall and or high speed stall	Reduce allowed maximum operation altitude	**3**	**1**	**minus 3**	**0**	**0**	**3**
12	Maximum climb rate > 2000 ft/min	Level bust due to high climb rate	Avionics that allow setting of target altitude and provides an alert if exceeded	**1**	**1**	**minus 5**	**0**	**0**	**1**
13	Maximum climb rate > 2000 ft/min	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia	Loss of pressure warning without delay plus aural warning.	**5**	**1 to 3**	**minus 5**	**0**	**0**	**5**
14	Aeroplane certified for steep approach	Hard landing due to steep approach	Take over CS-25 Steep Approach regulations	**1 to 2**	**1**	**minus 5**	**0**	**0**	**1 to 2**

No.	Threshold value	Incident type	Possible regulatory measures for CS-23	Effect on safety	Cost per aeroplane	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
15	Aeroplane certified for steep approach	Undershoot due to steep approach	Take over CS-25 Steep Approach regulations	**1**	**1**	**minus 5**	**0**	**0**	**1**
16	Service ceiling > 15,000 ft	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system due to high operating altitude => hypoxia	Loss of pressure warning without delay plus aural warning.	**5**	**1 to 3**	**minus 5**	**0**	**0**	**5**
17	Service ceiling > 25,000 ft or Service ceiling > 41,000 ft	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia	**Option A:** Oxygen dispensing units within easy reach that can be placed into position within 5 seconds **Option B:** Autopilot mode that brings the aeroplane in an emergency descent in case of loss of cabin pressure	**5** **5**	**3** **1**	**5** **minus 5**	**0** **0**	**0** **0**	**5** **5**
18	Service ceiling > 25,000 ft	Inability to reach airport before the battery that provides power to those loads that are essential for continued safe flight and landing	60 minutes battery capacity after loss of primary electrical power generation system	**1 to 3**	**1**	**5**	**0**	**0**	**1 to 3**

No.	Threshold value	Incident type	Possible regulatory measures for CS-23	Effect on safety	Cost per aeroplane	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
		is exhausted, in case of loss of primary electrical power generating system at high altitude (tbd ft)							
19	Service ceiling > 41,000 ft	Reduced flight crew performance due to poor ventilation at high altitude	Cabin ventilation requirements	**1**	**1 to 3**	**5**	**0**	**0**	**1**
20	Engine power on single engine propeller aeroplanes, weight (precise criterion to be developed)	Loss of control after applying power at low speeds near the stall (e.g. during approach or go-around) on single engine propeller aeroplanes with high power to weight ratio	**Option A:** Specific flight handling criteria for flights at low speeds near the stall with high engine power **Option B:** Artificial stall barrier system	5 **5**	**Unknown** as this is integral part of aircraft design **3**	**minus 5** **5**	**0** **0**	**0** **0**	5 **5**
Average values over all incidents:				**3.29**	**1.92**	**Minus 2,17**	**0**	**0**	**3,29**

Air Operations Regulations

No.	Threshold value	Incident type	Possible regulatory measures for Air Operations Regulations	Effect on safety	Cost per aeroplane	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
4b	Vmo > 250 kts or Mmo > 0.65 Or maximum climb rate > 2000 ft/min	Lagging behind events due to high speed or high climb rate => loss of separation	**Option A** ACAS with RA for commercial operations and non-commercial operations	**4**	**5**	**0**	**0**	**0**	**4**
			Option B ACAS for commercial operations, and Traffic Awareness System (TAS), Traffic Information System (TIS) or FLARM for non-commercial operations	**4** for commercial operators, **1** for non-commercial operators	**5** for commercial operators, **1** for non-commercial operators	**0**	**0**	**0**	**4** for commercial operators **1** for non-commercial operators
5	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed=> improper navigation in the vicinity of terrain (CFIT)	**Option A:** TAWS	**5**	**1**	**0**	**0**	**0**	**5**
			Option B: Synthetic vision or moving map display	**5**	**1-5**	**0**	**0**	**0**	**5**
17	Service ceiling > 15,000 ft	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia	Require a single pilot in the cockpit to wear an oxygen mask in certain high altitude conditions.	**5**	**0**	**5**	**0**	**0**	**5**
22	Not	Runway excursion due	Put single and twin	**5**	**0**	**0**	**0**	**0**	**5**

No.	Threshold value	Incident type	Possible regulatory measures for Air Operations Regulations	Effect on safety	Cost per aeroplane	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
	applicable	to insufficient runway length margins used for take-off and landing. CFIT due to insufficient obstacle or terrain clearance margins used for climb and en-route flight phases	engine jets with MCTOM < 5700 kg and MPSC < 9 in Performance Classes						
Average values over all incidents:				**4.56**	**2.75**	**1.25**	**0**	**0**	**4,38**

LAPL

No.	Threshold value	Incident type	Possible regulatory measures for LAPL	Effect on safety	Cost per pilot	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
13	Maximum climb rate > 2000 ft/min	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia	Hypoxia and procedural training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
16	Service ceiling > 15,000 ft	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system at high altitude => hypoxia	Hypoxia and procedural training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
17	Service ceiling > 15,000 ft	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia	Hypoxia and procedural training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
Average values over all incidents:				Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**

PPL

No.	Threshold value	Incident type	Possible regulatory measures for PPL	Effect on safety	Cost per pilot	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
1	Presence of speed brake without safety locks that prevent operation in flight regime for which it is not intended	Speed brake extended in flight regime where this is not permitted => stall	Procedural and recovery from stall training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
2	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => late communication to other crew members	Procedural training	Initially **2**, with experience **3**	**5**	**0**	**1**	**0**	Initially **2**, with experience **3**
3	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => late reporting to ATC	Procedural and use of avionics training	Initially **2**, with experience **3**	**5**	**0**	**1**	**0**	Initially **2**, with experience **3**
4a	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed => airspace infringement	Procedural training	Initially **1**, with experience **1**	**5**	**0**	**1**	**0**	Initially **1**, with experience **1**
4b	Vmo > 250 kts or Mmo > 0.65 Or Maximum climb rate > 2000 ft/min	Lagging behind events due to high speed or high climb rate => loss of separation	Procedural training	Initially **2**, with experience **4**	**5**	**0**	**1**	**0**	Initially **2**, with experience **4**
5	Vmo > 250 kts or Mmo > 0.65	Lagging behind events due to high speed =>	Procedural and use of avionics (TAWS)	Initially **3**, with	**5**	**0**	**1**	**0**	Initially **3**, with

No.	Threshold value	Incident type	Possible regulatory measures for PPL	Effect on safety	Cost per pilot	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
		improper navigation in the vicinity of terrain (CFIT)	training	experience **5**					experience **5**
6	Vmo > 250 kts	Lagging behind events due to high speed => failure to extend landing gear	Procedural training	Initially **2**, with experience **4**	**5**	**0**	**1**	**0**	Initially **2**, with experience **4**
7	Vmo > 250 kts or Mmo > 0.65	Fuel starvation (poor flight planning) due to high variation of fuel consumption with altitude and speed	Procedural training	Initially **2**, with experience **4**	**1**	**0**	**1**	**0**	Initially **2**, with experience **4**
8	Mmo > 0.65	Exceeding M_{MO} and high speed buffet => high speed stall	Recovery from stall training	Initially **2**, with experience **3**	**5**	**0**	**1**	**0**	Initially **2**, with experience **3**
9	Mmo > 0.65	Exceeding maximum operating altitude and flight near the coffin corner => low speed stall and/or high speed stall	Recovery from stall training	Initially **2**, with experience **4**	**5**	**0**	**1**	**0**	Initially **2**, with experience **4**
10	V_{REF} at MLAW > 100 kts	Hard landing due to high approach speed	Touch and go training	Initially **2**, with experience **3**	**5**	**0**	**1**	**0**	Initially **2**, with experience **3**
11	V_{REF} at MLAW > 100 kts	Long landing due to high approach speed	Touch and go training	Initially **2**, with experience **4**	**5**	**0**	**1**	**0**	Initially **2**, with experience **4**
12	Maximum climb	Level bust due to high	Procedural training	Initially **1**,	**5**	**0**	**1**	**0**	Initially **1**,

No.	Threshold value	Incident type	Possible regulatory measures for PPL	Effect on safety	Cost per pilot	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
	rate > 2000 ft/min	climb rate		with experience **1**					with experience **1**
13	Maximum climb rate > 2000 ft/min	Failure to timely detect failure in cabin pressurisation or supplemental oxygen system due to high climb rate => hypoxia	Hypoxia and procedural training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
14	Aeroplane certified for steep approach	Hard landing due to steep approach	Touch and go training	Initially **2**, with experience **3**	**5**	**0**	**1**	**0**	Initially **2**, with experience **3**
15	Aeroplane certified for steep approach	Undershoot due to steep approach	Touch and go training	Initially **1**, with experience **1**	**5**	**0**	**1**	**0**	Initially **1**, with experience **1**
16	Service ceiling > 15,000 ft	Failure to timely detect failure in cabin pressurisation system or supplemental oxygen system at high altitude => hypoxia	Hypoxia and procedural training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
17	Service ceiling > 15,000 ft	Failure to timely put on oxygen mask and/or perform emergency descent after rapid decompression at high altitude => hypoxia	Hypoxia and procedural training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
20	Engine power on single	Loss of control after applying power at low	Recovery from stall training	Initially **3**, with	**5**	**0**	**1**	**0**	Initially **3**, with

No.	Threshold value	Incident type	Possible regulatory measures for PPL	Effect on safety	Cost per pilot	Effort of regulatory harmonisation with FAA	Effect on employment	Effect on Environment	Effect on public health & safety
	engine propeller aeroplanes, weight (precise criterion to be developed)	speeds near the stall (e.g. during approach or go-around) on single engine propeller aeroplanes with high power to weight ratio		experience **5**					experience **5**
21	Significantly more difficult to handle in case of engine failure than average multi-engine CS-23 aeroplane (precise criterion to be developed)	Loss of control after engine failure on the ground or in flight on multi-engine aeroplane	Recovery from stall training	Initially **3**, with experience **5**	**5**	**0**	**1**	**0**	Initially **3**, with experience **5**
Average values over all incidents:				Initially **2,2**, with experience **3,65**	**4.8**	**0**	**1**	**0**	Initially **2,2**, with experience **3,65**

Recommended action

For each performance threshold that is exceed by an aeroplane type, take the most effective measures in the Certification Specifications, Air Operations Regulations and Flight Crew Licensing regulations. As it is up to the Agency the weigh the various effects against each other, the most effective measures can only be identified after the weighing factors have been set. Given the ratings of in particular the safety, cost and 'harmonisation with the FAA' effects, it is likely though that most effective measures will be spread over the three domains: Certification Specifications, Air Operations Regulations and Flight Crew Licensing regulations.

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Appendix 1 – Analysis of some performance parameters of HPA Jets and HPA propeller aircraft

Introduction

EASA has published a list of aircraft in which a number of aircraft models are classified as High Performance aircraft HPA. To obtain some insight into a number of performance characteristics of these EASA HPA classified aircraft a comparison is made with a number of comparable aircraft that are currently not considered a HPA. Jet powered aircraft and propeller driven aircraft are discussed separately.

HPA Jet aircraft

Performance data of jet powered aircraft that are currently considered HPA aircraft by EASA are compared to *multi-pilot* Part 25 certified non HPA jet powered aircraft. Note that currently all *single pilot* operated jet aircraft identified are considered HPA by EASA. These are all certified according to CS-23 or equivalent regulations. The reference non HPA aircraft used are all business jet aircraft types certified according to CS-25 or equivalent regulations as these aircraft closely match the general design of many HPA jet aircraft.
All data were obtained from Aircraft Flight Manuals supplemented with information from aircraft brochures, and Jane's All the World's Aircraft. The total data sample comprises of 31 aircraft: 18 HPA and 13 non HPA.

Climb rate

The climb rate of a jet power aircraft is determined by a number of factors including wing loading, thrust-over-weight ratio, lift coefficient and drag-over-lift ratio. These factors also influence the maximum climb rate. The thrust-over-weight ratio typically has a dominant influence on the maximum climb rate. Also wing loading has a strong influence.
Figure A.1 shows the thrust-over-weight ratio versus wing loading of HPA jet aircraft compared to non HPA business jet aircraft from the data sample. This shows that the thrust-over-weight ratios of both HPA jets and non HPA jets in the data sample are very similar to each other. The wing loading is typically lower for the HPA jet aircraft in order to keep the landing distances acceptably low for these aircraft. The HPA jet aircraft often have simple high-lift devices installed and no ground spoilers and/or antiskid which normally will increase the landing distance. A low wing loading is then important to reduce the landing distance. The higher cruise speed of many of the non HPA jet aircraft in the data sample will also affect the higher wing loading of these aircraft.
The all-engine climb rate at Sea Level & MTOW for HPA jet aircraft and non HPA business jet aircraft as function of thrust-over-weight ratio, is shown in **Figure A.2**. This figure shows that for a given T/W ratio the climb rates of both HPA and non HPA aircraft are similar. Differences are most likely caused by the differences in wing loading and aerodynamic characteristics.

Figure A.1 Thrust-over-weight ratio versus wing loading of HPA jet aircraft compared to non HPA business jet aircraft

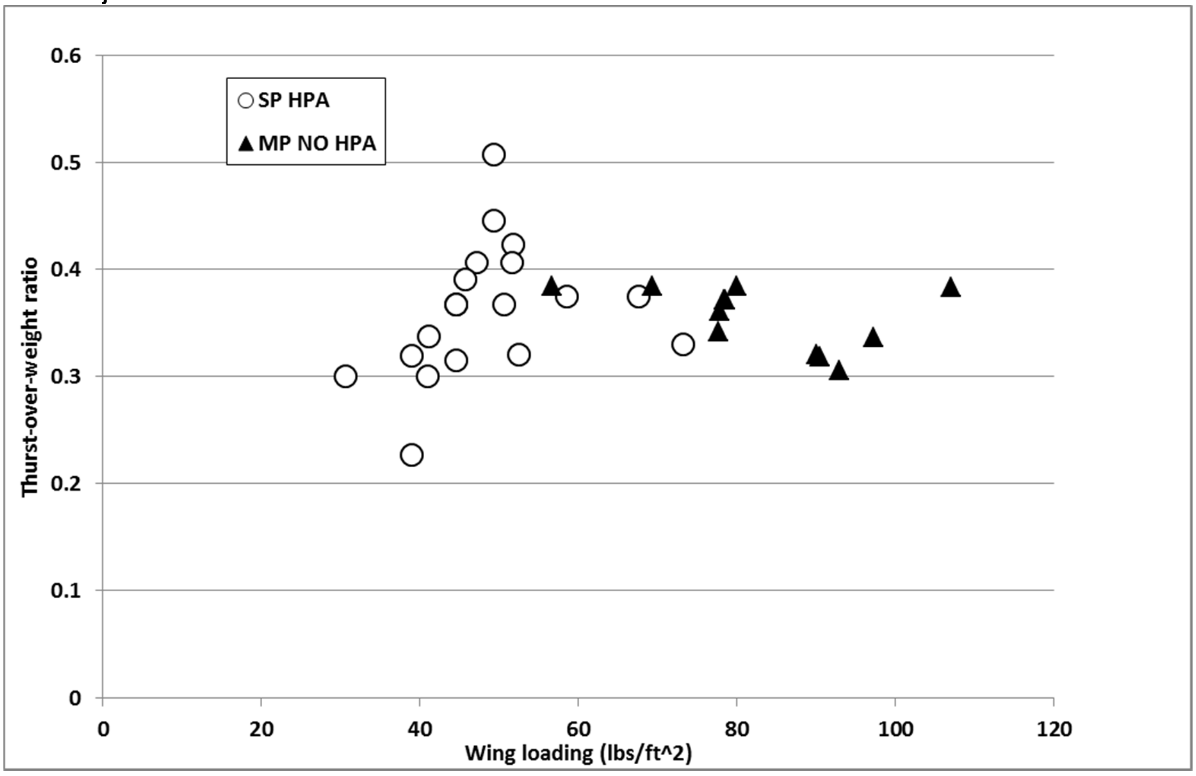
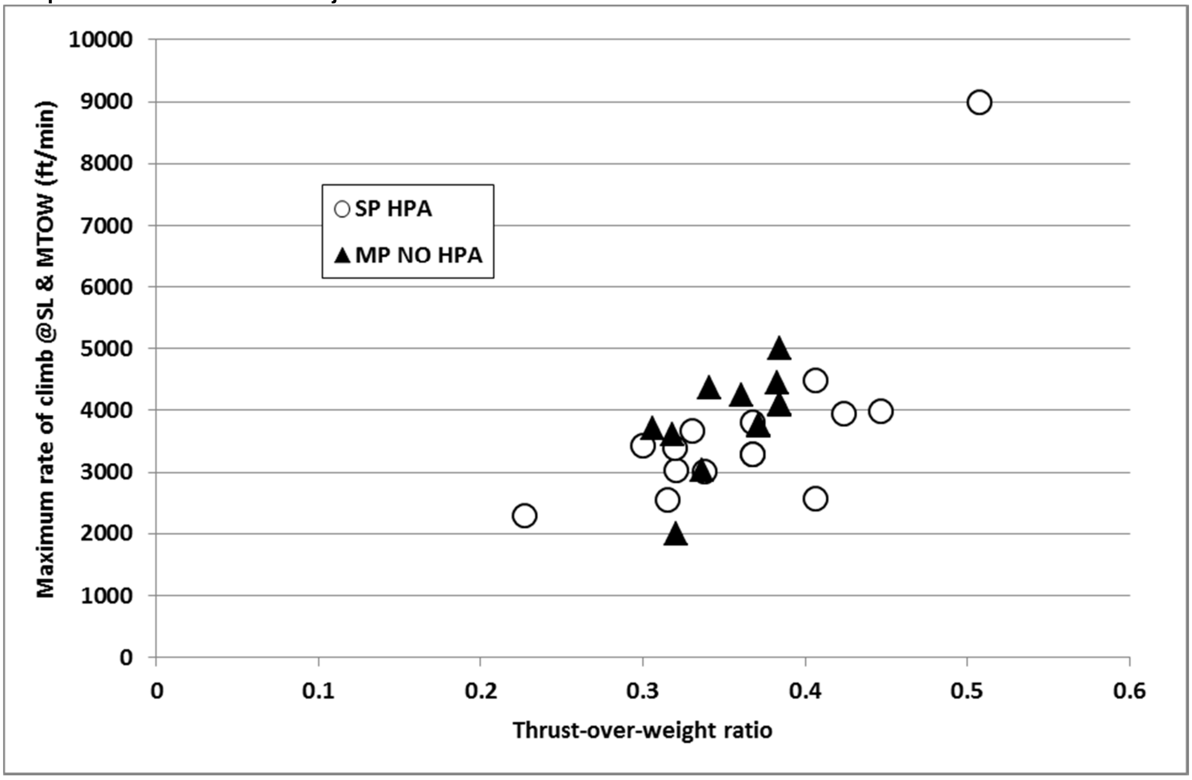


Figure A.2 Thrust-over-weight ratio versus maximum all engine rate of climb of HPA jet aircraft compared to non HPA business jet aircraft



Maximum operating speeds

Vmo/Mmo are the Maximum Operating Limit Speeds that may not be deliberately exceeded in any regime of flight (climb, cruise, or descent). Exceeding Vmo/Mmo can pose a threat to exceeding design structural integrity and design stability & control criteria of the aircraft. Every aircraft has an operating limit speed Vmo that must not be exceeded. Aircraft can also become disturbingly unstable at transonic speeds. Such a problem is unacceptable during normal flight and therefore the speed is limited by the maximum operating Mach number MMO. The maximum operating Mach number depends on the wing design. Factors like wing sweep angle, airfoil thickness, and airfoil type (e.g. conventional or supercritical) influence the maximum operating Mach number. **Table A.1**A.1 gives an overview of the operating speed limits of both the HPA and the non HPA jet aircraft in the data sample. The non HPA aircraft in the data sample have on average higher speed limits than the HPA jet aircraft. This is attributable to the differences in wing design of these aircraft. For instance HPA jet aircraft have typically wings with only little to no sweep which lowers the Mmo. The high maximum Mmo of 0.89 for the HPA jet aircraft in the sample is for the Javelin MK-10 which has a relatively high wing sweep.

Table A.1 Maximum operating speeds HPA and non HPA jets

Type	Operating speed	Average	Minimum	Maximum
HPA	Vmo (KIAS)	303	250	500
HPA	Mmo	0.72	0.54	0.89
Non HPA	Vmo (KIAS)	337	305	370
Non HPA	Mmo	0.85	0.80	0.94

Ceiling

The average allowable operating altitude determined by airworthiness authorities for HPA and non HPA jet aircraft from the data sample listed in **Table A.2**. The average ceilings are very similar as well as the maximum ceiling in the data sample for both HPA and non HPA.

Table A.2 Certified ceiling (ft.) HPA and non HPA jets

Type	Average	Minimum	Maximum
HPA	42,263	28,000	49,000
Non HPA	45,833	41,000	51,000

Rate of descent

Maximum rate of descent is mainly determined by the wing loading and the aerodynamics of the aircraft. A high wing loading and high aerodynamic drag are favourable for a high rate of descent. The HPA jets in the data sample have lower wing loadings than non HPA jets in the data sample. Furthermore the HPA jets are often not equipped with speed brakes that can increase the aerodynamic drag. The maximum rate of descent of HPA jets will therefore be less than non HPA jets.

Take-off and landing performance

Figure A.3 shows the take-off distance as function of speed at the screen height of HPA jet aircraft and non HPA business jet aircraft. Also shown are lines of constant average acceleration from the start of the ground roll until reaching the screen height. The data show that HPA jets do not accelerate much faster during the take-off than non HPA jets in the data sample.

Figure A.3 Takeoff distance as function of speed at the screen height of HPA jet aircraft and non HPA business jet aircraft

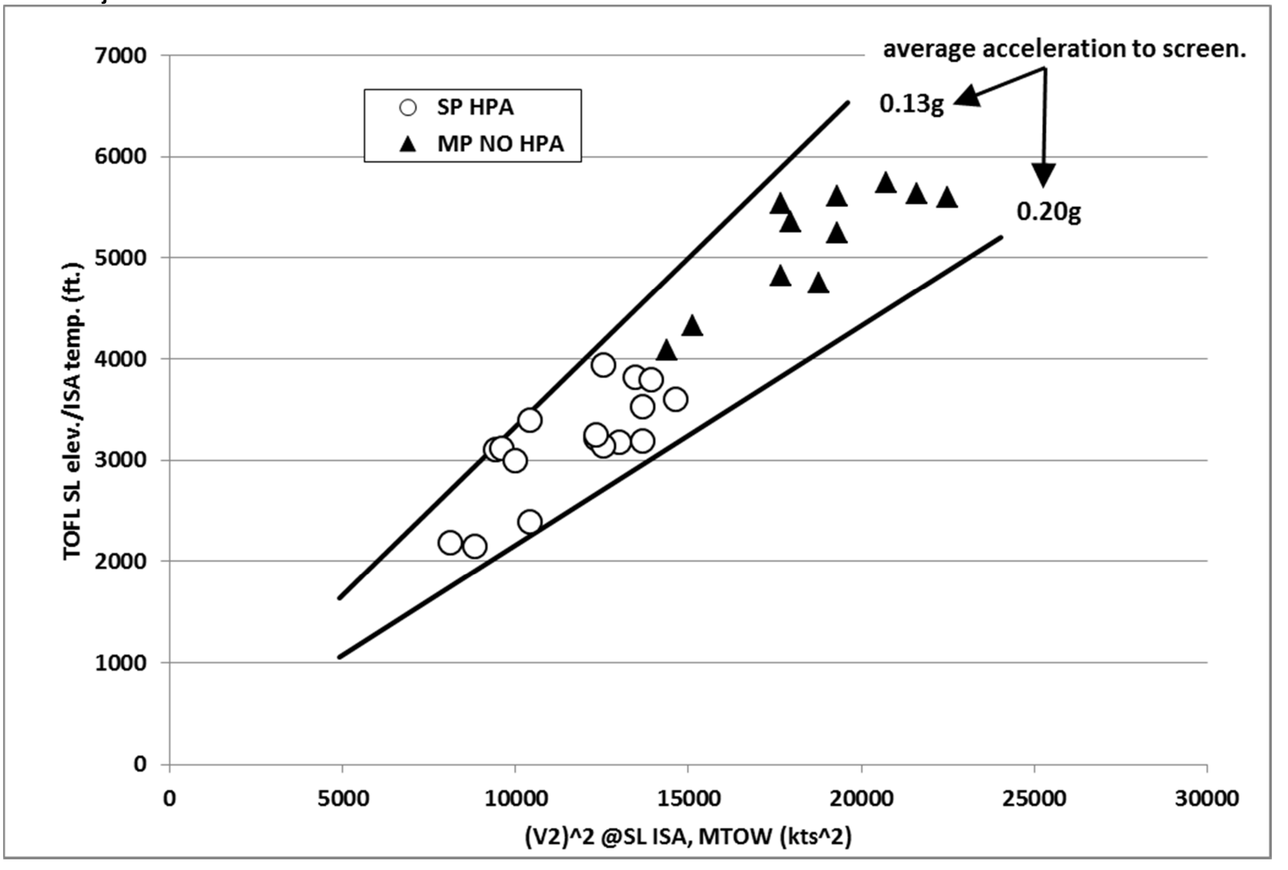
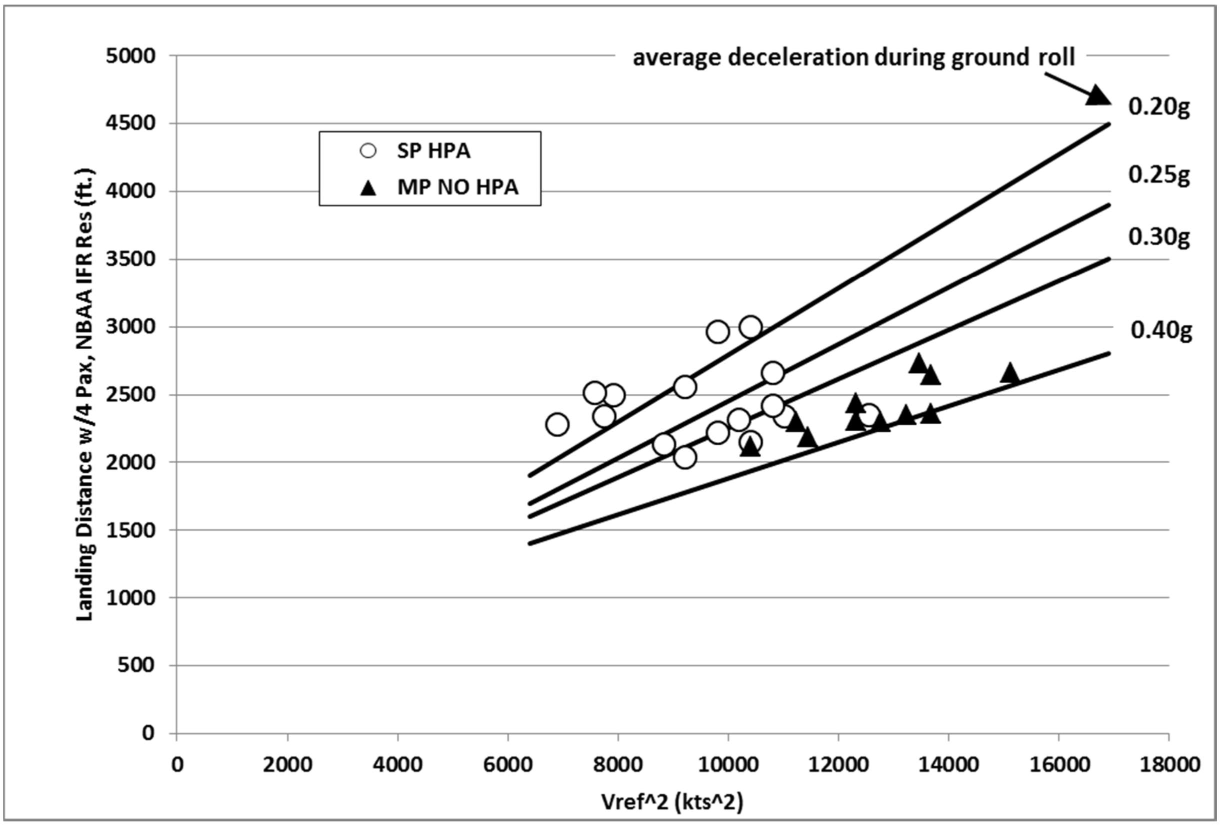


Figure A.4 shows the landing distance from 50 ft screen height of HPA jet aircraft and non HPA business jet aircraft. Also shown are lines of contact deceleration during the ground roll. Most HPA jets from the data sample have ground decelerations during the landing roll that are similar or less than non HPA jet aircraft. Landing ground deceleration of less than 0.25g are typically for aircraft that are not equipped with an antiskid and or ground spoilers. This is common for HPA jet aircraft designs in the data sample.

Figure A.4 Landing distance from 50 ft screen height of HPA jet aircraft and non HPA business jet aircraft



HPA Propeller aircraft

Performance data of propeller aircraft that are currently considered HPA aircraft by EASA are compared to non HPA propeller aircraft with a MTOW of less than 16500 lbs. Both single and multi-engine piston and turboprop aircraft are considered. All data were obtained from Aircraft Flight Manuals supplemented with information from aircraft brochures, and Jane's All the World's Aircraft. The total data sample comprises of 50 aircraft: 18 HPA and 32 non HPA.

Climb performance

The climb rate of a propeller aircraft is determined a number of factors including wing loading, power-over-weight ratio, and aircraft aerodynamic characteristics. These factors also influence the maximum climb rate. The power-over-weight ratio typically has a dominant influence on the maximum climb rate. The maximum climb rate increases linear with the power-over-weight ratio. Also wing loading has a strong influence. The maximum climb rate decreases with increasing wing loading but this effect is less strong than the influence of the power-over-weight ratio.

Figure A.5 shows the relation between power-over-weight ratio and the wing loading for HPA propeller aircraft and non HPA propeller aircraft. The HPA propeller aircraft tend to have a higher power-over-weight and wing loading than non HPA propeller aircraft. The crossover point between both categories lies around 0.1 for the power loading and around 40 lbs/ft^2 of wing loading. A higher power loading will have a positive influence on the maximum climb rate whereas a high wing loading has the opposite effect. In **Figure A.6** a comparison of maximum climb arte is given for HPA propeller aircraft and non HPA propeller aircraft. This shows that most of the HPA aircraft have a higher climb rate mainly caused by the higher power loading. The higher wing loading of HPA propeller aircraft apparently does not have a large negative impact on the maximum climb rate. The crossover point lies at a maximum climb rate of around 1700-2000 ft/min.

Figure A.5 Power-over-weight ratio versus wing loading of HPA propeller aircraft compared to non HPA propeller aircraft

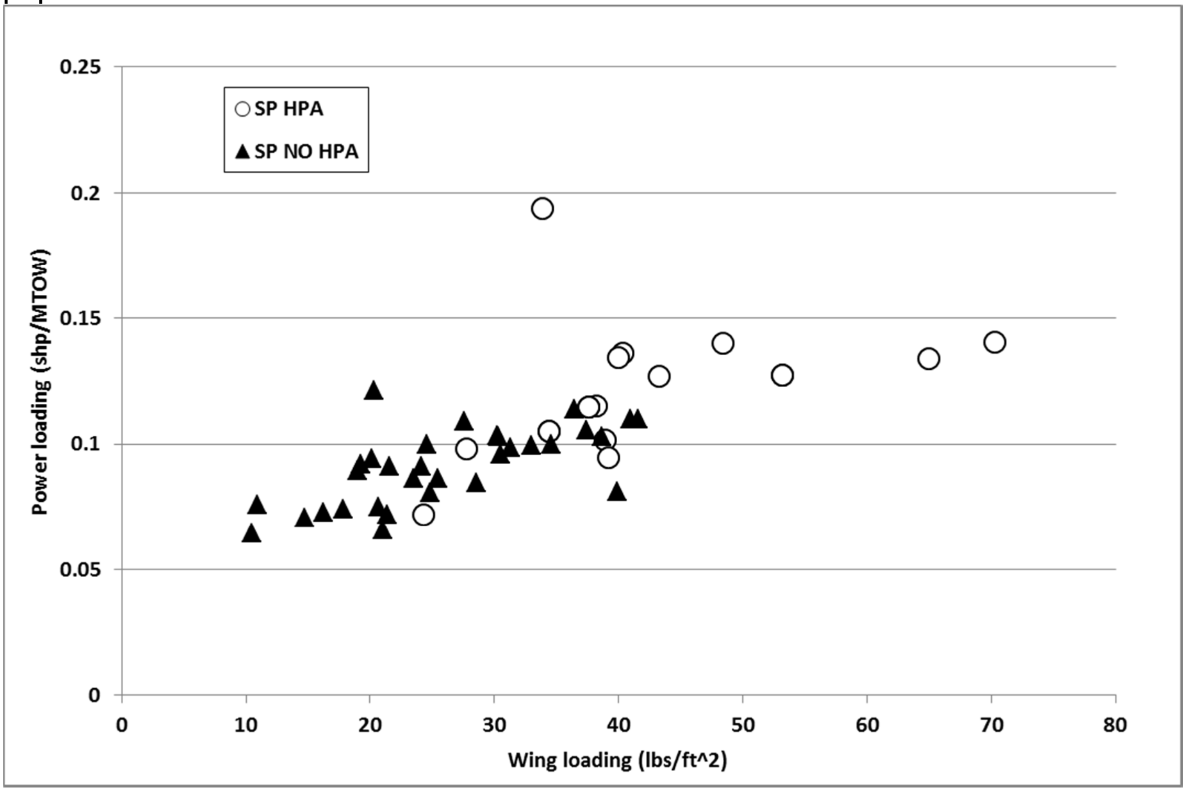
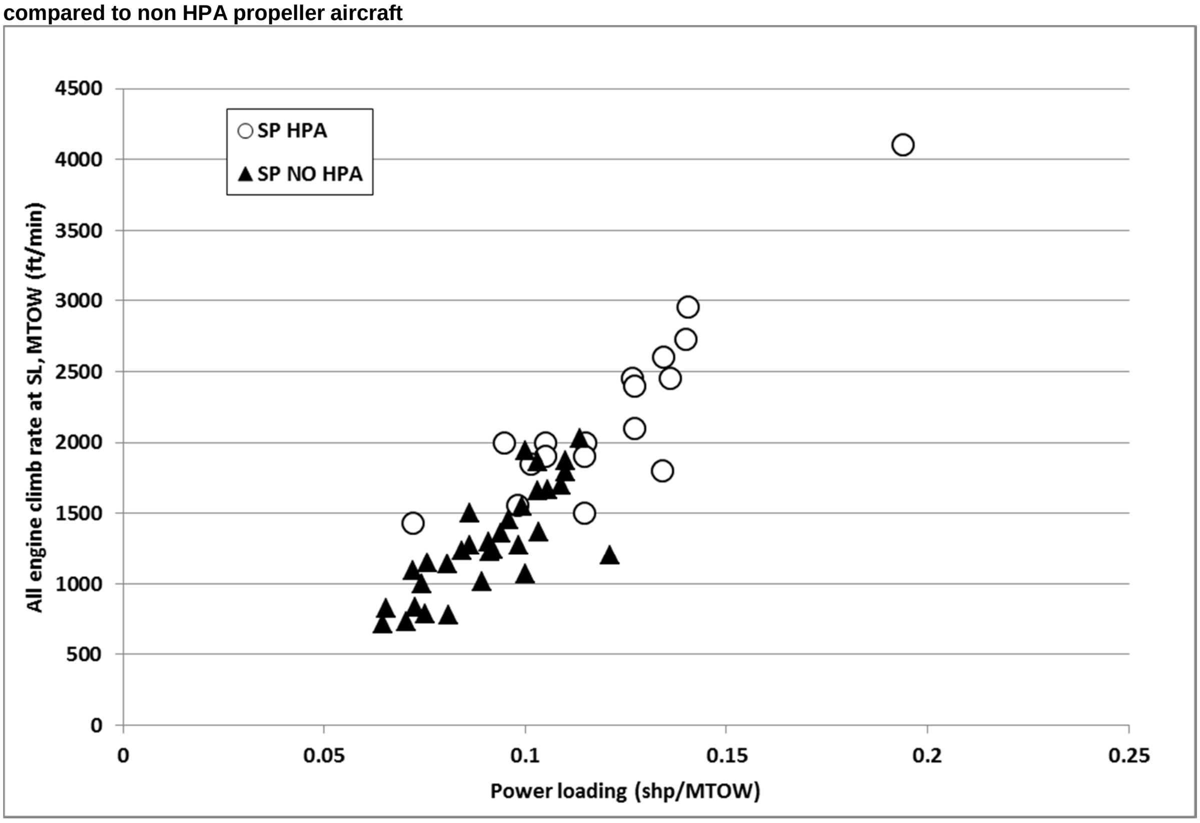


Figure A.6 Power-over-weight ratio versus maximum all engine rate of climb of HPA propeller aircraft compared to non HPA propeller aircraft



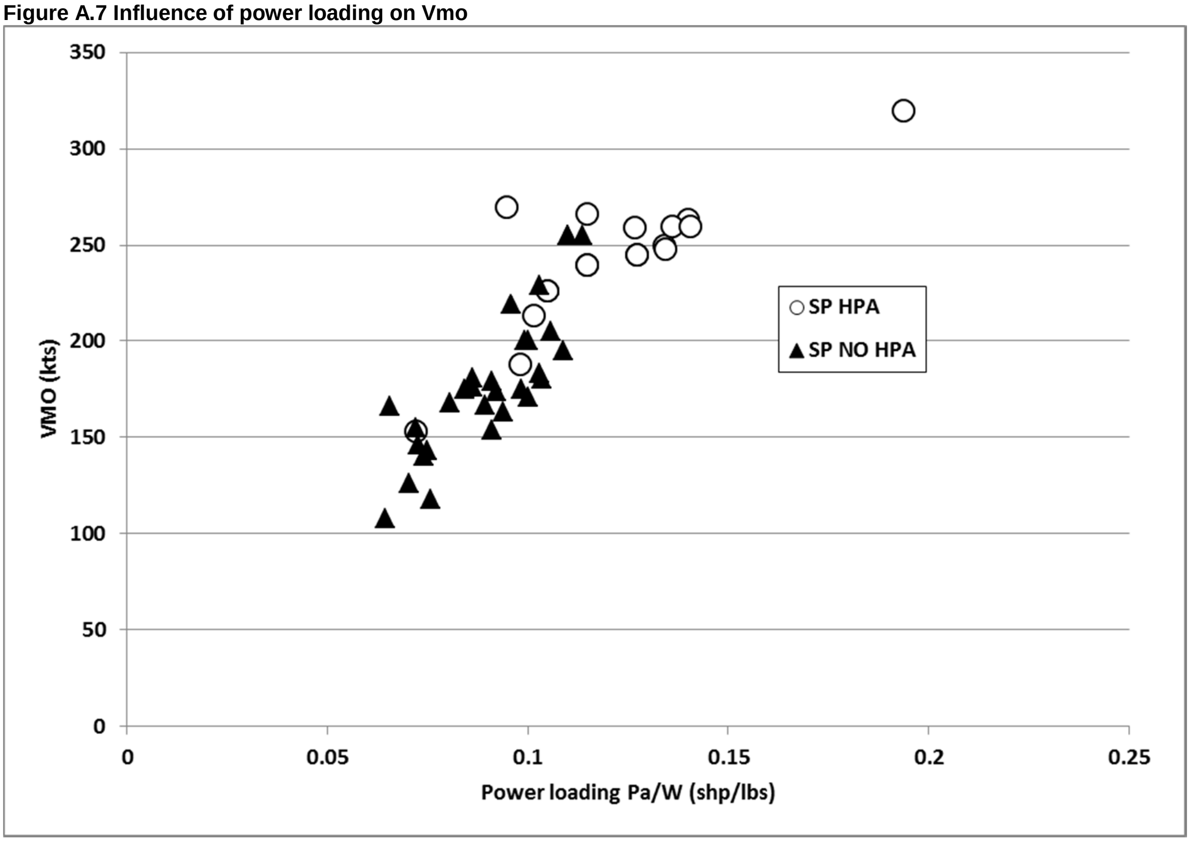
Maximum operating speeds

Vmo is the Maximum Operating Limit Speed that may not be deliberately exceeded in any regime of flight (climb, cruise, or descent). Exceeding Vmo can pose a threat to exceeding design structural integrity and design stability & control criteria of the aircraft. Every aircraft has an operating limit speed Vmo that must not be exceeded. Aileron design, wing aspect ratio and angle of wing sweep are amongst the factors that determine Vmo. The average Vmo and the range of Vmo values for HPA propeller aircraft and non HPA propeller aircraft from the data sample are listed in Table A.. HPA propeller aircraft have on average a higher Vmo than non HPA propeller aircraft. This is mainly the results of the higher power loadings of these aircraft (see **Figure A.7**).

Table A.3 Vmo (kts) for HPA and non HPA propeller aircraft

Type	Average	Minimum	Maximum
HPA	243	153	320
NO HPA	179	108	255

Figure A.7 Influence of power loading on Vmo



Ceiling

The average allowable operating altitude determined by airworthiness authorities for HPA and non HPA propeller aircraft from the data sample listed in Table A.4. The average ceilings for HPA are much higher than for non HPA propeller aircraft. Most of the HPA propeller aircraft in the data sample have pressurised cabins which allows them to fly at higher altitudes than non HPA propeller aircraft in the data sample for which most are unpressurised.

Table A.4 Certified ceiling (ft.) HPA and non HPA propeller aircraft

Type	Average	Minimum	Maximum
HPA	33,111	25,000	50,000
NO HPA	22,502	14,000	33,400

Rate of descent

Maximum rate of descent is mainly determined by the wing loading and the aerodynamics of the aircraft. A high wing loading and high aerodynamic drag are favourable for a high rate of descent. The HPA propeller aircraft in the data sample have higher wing loadings than non HPA propeller aircraft in the data sample. The maximum rate of descent of HPA propeller aircraft could therefore be higher than non HPA propeller aircraft.

Take-off and landing performance

Figure A.8 shows the take-off distance as function of speed at the screen height of HPA propeller aircraft and non HPA propeller aircraft. Also shown are lines of constant average acceleration from the start of the ground roll until reaching the screen height. The data show that HPA propeller aircraft do not accelerate much faster during the take-off than non HPA propeller aircraft in the data sample.

Figure A.8 Take-off distance as function of speed at the screen height of HPA propeller aircraft and non HPA propeller aircraft

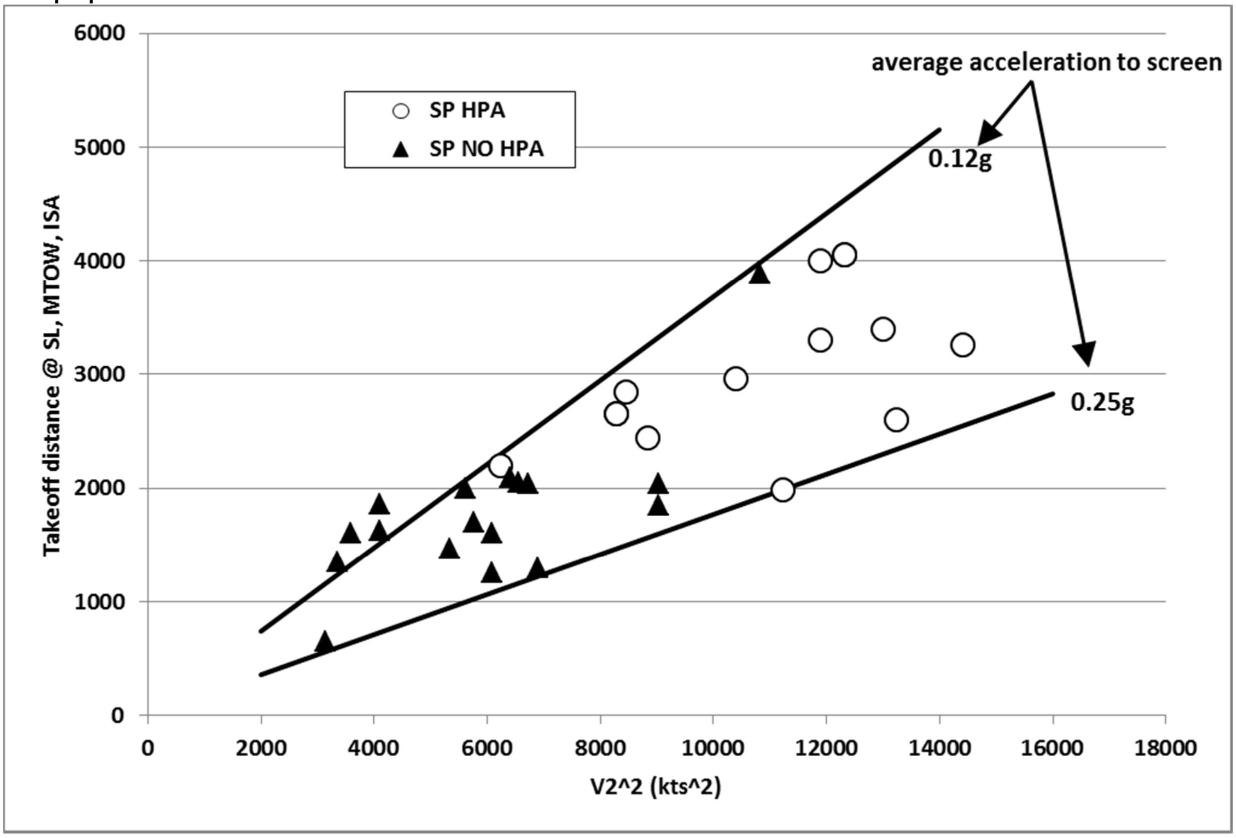
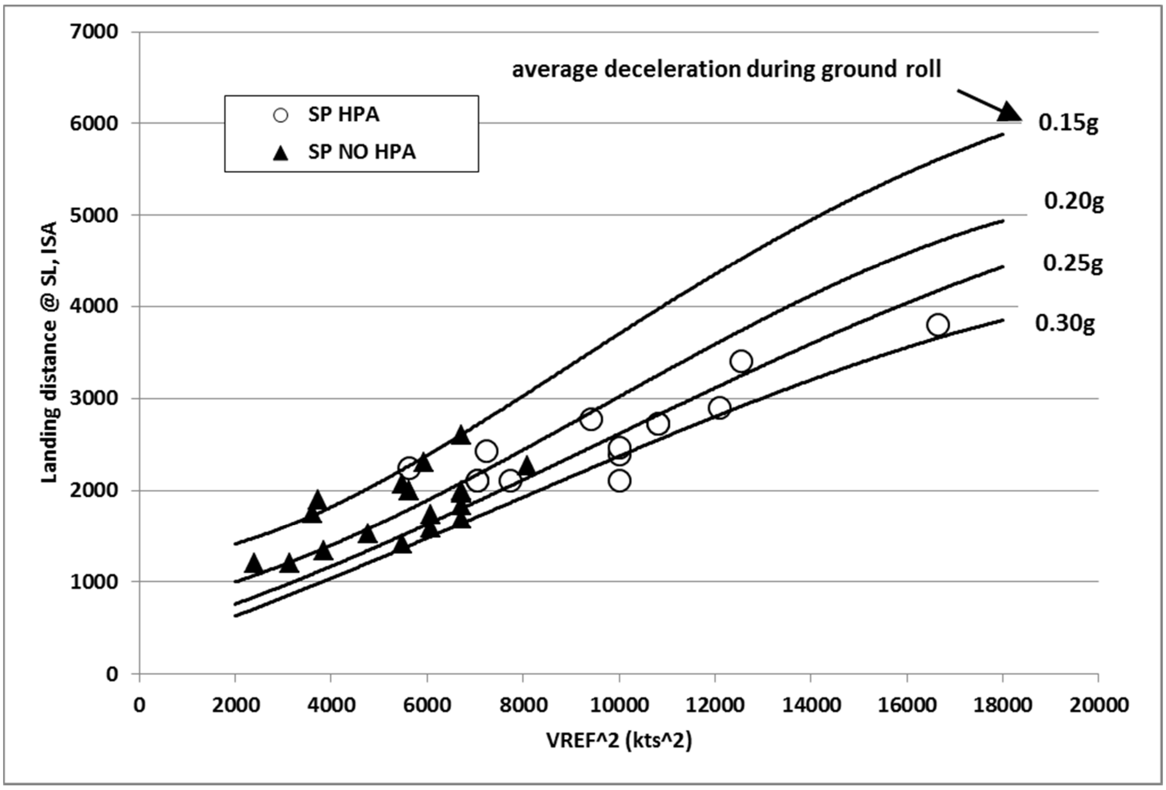


Figure A.9 shows the landing distance from 50 ft screen height of HPA propeller aircraft and non HPA propeller aircraft. Also shown are lines of contact deceleration during the ground roll. Most HPA propeller aircraft from the data sample have ground decelerations during the landing roll that are similar or higher than non HPA propeller aircraft, in the order of 0.20g -0.30g. Light single-piston-engined aircraft (non HPA) typically have a ground deceleration of 0.15g-0.20g.

Figure A.9 landing distance from 50 ft screen height of HPA propeller aircraft and non HPA propeller aircraft



Appendix 2 – Performance data – Propeller Aircraft

Manufacturer	Type	Seating	Wing Loading	Power Loading Shp/W lbf/lb	# of engines	Engine type	Output (shp each)	Max Takeoff (lbs.)	MMO	Trans. Alt. FL	VMO	All eng climb rate (ft./min)	Certificated ceiling (ft.)
Textron Aviation	Beechcraft King Air 250 EP	1+8/10	43.3	0.127	2	Turboprop	850	13,420	0.58	FL 210	259	2,450	35,000
Textron Aviation	Beechcraft King Air 350i	1+9/11	48.4	0.140	2	Turboprop	1,050	15,000	0.58	FL 210	263	2,731	35,000
Textron Aviation	Beechcraft King Air 350HW	1+9/14	53.2	0.127	2	Turboprop	1,050	16,500	0.58	FL 240	245	2,100	35,000
Textron Aviation	Beechcraft King Air 350iER	1+9/11	53.2	0.127	2	Turboprop	1,050	16,500	0.58	FL 240	245	2,400	35,000
Mitsubishi	MU-2B	1+ 11	65	0.134	2	Turboprop	776	11,575	0.57	FL 210	250	1,800	25,000
Nextant Aerospace	C90	1+7/10	34.4	0.105	2	Turboprop	550	10,485			226	2,000	30,000
Textron Aviation	C90GTi	1+7/8	34.4	0.105	2	Turboprop	550	10,485			226	1,900	30,000
GECI Aviation	F406	1+8/13	38.9	0.102	2	Turboprop	500	9,850			213	1,850	30,000
Textron Aviation	Beechcraft King Air 250	1+8/10	40.3	0.136	2	Turboprop	850	12,500			260	2,450	35,000
Piaggio Aero Industries	P180	1+7/9	70.3	0.140	2	Turboprop	850	12,100			260	2,953	41,000
Swearingen	SA226	1+	40	0.134	2	Turboprop	840	12,500			248	2,600	25,000
Piper Aircraft	PA-46-500TP	1+4/5	27.8	0.098	1	Turboprop	500	5,092			188	1,556	30,000
Socata	TBM 900, 700 N	1+5/6	38.2	0.115	1	Turboprop	850	7,394			266	2,000	31,000
Pilatus	PC-12 NG	1+7/10	37.6	0.115	1	Turboprop	1,200	10,450			240	1,900	30,000
Socata	TBM TBM 850 700 N	1+5/6	39.2	0.095	1	Turboprop	700	7,394			270	2,000	31,000
Pilatus	PC-12 Series 10 PC-12/47	1+7/10	37.6	0.115	1	Turboprop	1,200	10,450			240	1,500	30,000
Pilatus	PC-9	1+	33.9	0.194	1	Turboprop	1,149	5,940			320	4,100	38,000

Manufacturer	Type	Seating	Wing Loading	Power Loading Shp/W lbf/lb	# of engines	Engine type	Output (shp each)	Max Takeoff (lbs.)	MMO	Trans. Alt. FL	VMO	All eng climb rate (ft./min)	Certificated ceiling (ft.)
Grob	G520 T (NG)	1+	24.3	0.072	1	Turboprop	750	10,361			153	1,430	50,000
Dornier	228-100	1+	36.48	0.114	2	Turboprop	715	12,556	0.4	FL 150	255	2,027	28,000
Dornier	228-203F	1+	41.6	0.110	2	Turboprop	776	14,330	0.4		255	1,791	28,000
Dornier RUAG	228-212	1+	41	0.110	2	Turboprop	776	14,109	0.4		255	1,870	28,000
Pilatus-Britten	BN2T turbine Ilsander	1+	20.3	0.121	2	Turboprop	400	6,600				1,200	25,000
Vulcanair SpA	AP68TP-600	1+7/10	33	0.099	2	Turboprop	328	6,613			200	1,550	25,000
Evektor	EV-55	1+9/14	37.4	0.106	2	Turboprop	536	10,141			205	1,663	24,000
Textron Aviation	CE-208	1+9/13*	28.6	0.084	1	Turboprop	675	8,000			175	1,234	25,000
Quest Aircraft	Kodiak 100	1+5/9	30.2	0.103	1	Turboprop	750	7,255			180	1,371	25,000
Textron Aviation	CE-208B	1+9/13*	31.3	0.098	1	Turboprop	867	8,807			175	1,275	25,000
EXTRA	Extra Aircraft EA 500	1+5/5	30.5	0.096	1	Turboprop	450	4,696			219	1,450	25,000
Pilatus	PC-6	1+	19	0.089	1	Turboprop	550	6,137			167	1,010	25,000
PACIFIC AEROSPACE LIMITED	PAc750XL	1+	24.6	0.100	1	Turboprop	750	7,500			171	1,067	20,000
Air Tractor	AT802A	1+1	39.9	0.081	1	Turboprop	1,295	16,000				780	
Cirrus Design	SR20	1+3/4	21	0.066	1	Piston	200	3,050			166	828	17,500
Piper	PA-28R-201	1+3/3	16.2	0.073	1	Piston	200	2,750			146	831	16,200
Cirrus Design	Sr22	1+3/4	23.5	0.086	1	Piston	310	3,600			176	1,270	17,500
Mooney	M-20R	1+3/4	19.3	0.092	1	Piston	310	3,368			174	1,240	
GippsAero	GA8	1+6/7	20.7	0.075	1	Piston	300	4,000			143	788	20,000
Cessna	Skylane CE-182T	1+3/3	17.8	0.074	1	Piston	230	3,100			140	1,000	18,100
Lancair	Columbia 350 LC42-550FG	1+3/3	24.1	0.091	1	Piston	310	3,400			179	1,225	18,000
Lancair	Columbia 400 LC41-550-FG	1+3/4	25.5	0.086	1	Piston	310	3,600			181	1,500	25,000
Textron Aviation	CE-172SP	1+	14.7	0.070	1	Piston	180	2,250			126	730	14,000
Textron Aviation	CE-152	1+	10.5	0.065	1	Piston	108	1,670			108	715	14,000
Ultra	Sting	1+	10.9	0.076	1	Piston	100	1,320			118	1,150	

Manufacturer	Type	Seating	Wing Loading	Power Loading Shp/W lbf/lb	# of engines	Engine type	Output (shp each)	Max Takeoff (lbs.)	MMO	Trans. Alt. FL	VMO	All eng climb rate (ft./min)	Certificated ceiling (ft.)
Piper Aircraft	PA-46R-350	1+4/5	24.8	0.081	1	Piston	350	4,340			168	1,143	25,000
Piper aircraft	PA-34-200T	1+	20.1	0.094	2	piston	200	4,200			163	1,360	17,900
Cessna	310R	1+	30.3	0.103	2	piston	283	5,500			183	1,662	19,750
Diamond	DA42	1+	21.4	0.072	2	piston	135	3,748			155	1,090	18,000
Beechcraft	Baron 58	1+	27.6	0.109	2	piston	300	5,500			195	1,700	
Cessna	Model 425	1+	38.7	0.103	2	piston	450	8,675			229	1,861	33,400
Cessna	Model 421C	1+	34.6	0.100	2	Piston	375	7,450			200	1,940	30,200
Beechcraft	76	1+	21.6	0.091	2	Piston	180	3,916			154	1,300	
ATR	ATR-42		56	0.11	2	Turboprop	2,150	33,000	0.55		250	2,100	25,000

Appendix 3 – Performance data – Jet Aircraft

Manufacturer	Type	Seating	Wing loading (MTOW/S) lbs/ft^2	T/W	Max Takeoff weight lbs	MMo	Trans. Alt. FL/VMo	VMo	All engine climb rate (ft/min)	Certificated ce
Eclipse Aviation	Eclipse Aviation EA 500	1+4/5	39	0.32	5,640	0.64	FL 200	285	3,400	41,000
Cirrus Design	Vision SF-50	1+4/6	30.7	0.30	6,000	0.54	FL 195	250		28,000
Eclipse Aerospace	Eclipse 550	1+4/5	41	0.30	6,000	0.64	FL 200	285	3,424	41,000
Aviation Technology Group	Javelin MK-10	1+	49.3	0.51	6,900	0.89		500	9,000	45,000
Adam	Adam Aircraft A700	1+5/7	44.6	0.32	7,600	0.63	FL 280	260	2,550	41,000
Aerospatiale	MS 760 Paris	1+	39	0.23	7,725	0.7		420	2,300	25,000
Textron Aviation	Citation Mustang CE-510	1+5/5	41.2	0.34	8,645	0.63	FL 271	250	3,010	41,000
Honda Aircraft	HondaJet HA-420	1+5/6	49.4	0.45	9,200	0.72	FL 300		3,980	43,000
Embraer	Phenom 100E EMB-500	1+5/7	52.5	0.32	10,582	0.7	FL 280	275	3,030	41,000
Textron Aviation	Cessna Citation M2 CE-525	1+7/7	44.6	0.37	10,700	0.71	FL 305	263	3,290	41,000
Cessna	CJ1+ CE-525	1+7/7	44.6	0.37	10,700	0.71	FL 305	263	3,290	41,000
Beechcraft	Premier IA, 390	1+6/7	50.6	0.37	12,500	0.8	FL 280	320	3,800	41,000
Textron Aviation	Cessna Citation CJ3+ CE-525B	1+8/9	47.2	0.41	13,870	0.737	FL 293	278	4,478	45,000
Grob SPn Utilijet	G180	1+8/9	51.6	0.41	13,889	0.7	FL 284	272	2,570	41,000
Syberjet	SJ30i SJ30-2	1+5/6	73.2	0.33	13,950	0.83	FL 295	320	3,663	49,000
Cessna	Citation Bravo, CE-550	2+7/8	45.8	0.39	14,800	0.7	FL 279	275	3,190	45,000
Nextant Aerospace	Nextant 400 Xti BE 400A	2+7/9	67.6	0.37	16,300	0.78	FL 290	320		45,000
Textron Aviation	Cessna Citation CJ4 CE-525C	2+8/9	51.8	0.42	17,110	0.77	FL 279	305	3,945	45,000
Embraer	Phenom 300 EMB-505	1+7/10	58.6	0.37	17,968	0.78	FL 263	320		45,000
Textron Aviation	Citation Sovereign+ CE-680	2+9/12	56.7	0.38	30,775	0.8	FL 298	305	4,083	47,000
Textron Aviation	Cessna Citation X+ CE-750	2+9/12	69.4	0.38	36,600	0.935	FL 307	350	4,117	51,000
Embraer	Legacy 500 EMB-550	2+8/12	78.6	0.37	37,919	0.83	FL 295	320	3,750	45,000
Gulfstream Aerospace	Gulfstream 280 G280	2+10/19	80	0.38	39,600	0.85	FL 280	340	5,000	45,000
Bombardier	Challenger 350 BD-100-1A10	2+9/11	77.8	0.36	40,600	0.83	FL 290	320	4,240	45,000
Dassault	Falcon 2000EX	2+10/19	77.7	0.34	41,000	0.862	FL 250	370	4,375	47,000

Manufacturer	Type	Seating	Wing loading (MTOW/S) lbs/ft^2	T/W	Max Takeoff weight lbs	MMo	Trans. Alt. FL/VMo	VMo	All engine climb rate (ft/min)	Certificated ce
Bombardier	CL-600-2B16	2+10/19	107.1	0.38	48,200	0.85	FL 222	348	4,450	41,000
Dassault	Falcon 900EX	2+12/19	92.9	0.31	49,000	0.87	FL 250	370	3,700	51,000
Embraer	Legacy 600 EMB-135BJ	2+13/14	90	0.32	49,604	0.8	FL 276	320	2,000	41,000
Embraer	Legacy 650 EMB-135BJ	2+13/14	97.2	0.34	53,572	0.8	FL 276	320	3,022	41,000
Gulfstream Aerospace	Gulfstream 450 GIV-X	2+14/19	78.4	0.37	74,600	0.88	FL 280	340	3,760	45,000
Bombardier	Global 5000 BD-700-1A11	3+13/19	90.5	0.32	92,500	0.89	FL 303	340	3,600	51,000
Boeing	B737-800		129	0.30	174,000	0.82	FL 260	340	≈4,000	41,000
Boeing	B777-200		119	0.28	545,000	0.89	FL 317	330	≈3,000	41,000

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