Comparison between Performance Requirements for Certification and Performance Requirements for Operation of Transport Category Rotorcraft

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ABSTRACT

In order to achieve aviation safety, integrity of two pillars is essential: product and operations. Regarding product integrity of transport category rotorcraft, its requirements are established in USA by the Federal Aviation Administration (FAA) Part 29, as Categories A and B. Regarding rotorcraft operations, the International Civil Aviation Organization (ICAO) has established Performance Classes 1, 2 and 3 in its Annex 6 Part III, determining they shall occur under a Code of Performance established by the State of the Operator. Should operations neglect certification requirements, particularly certification performance operating limitations, the intended protection (i.e., aviation safety) remains, therefore, unassured. This is possibly the case with offshore operations, pushed by a supposed commercial viability (increased payload) for oil and gas industry. Aiming to clarify it, the authors critically peruse through an exploratory and qualitative research of historical and bibliographic documentation of both rotorcraft certification and operation issued by ICAO and FAA and, in doing so, enhance understanding of the overlaps and complementarity (or otherwise) of certification and operational performance requirements for transport category rotorcraft.

Keywords: Certification; Flight operations; Helicopter performance; Flight safety; Offshore operations.

INTRODUCTION

The focus of any national aviation authority is aviation safety. In order to achieve it, the integrity of two pillars is essential: product and operations. Regarding product integrity, certification ensures that aircraft meets the minimum necessary performance for a safe operation for its passengers, assets, third parties, properties and persons in its flight path.

Beyond product integrity, it is also necessary to ensure the integrity of operations, which involves compliance with all operational regulations, general operating and flight rules, crew training, safety programs, standard operating procedures and so on. Additionally, there must be an intrinsic relationship between product integrity and operations integrity in order to achieve continuing operational safety and, thereby, aviation safety (Fig. 1).

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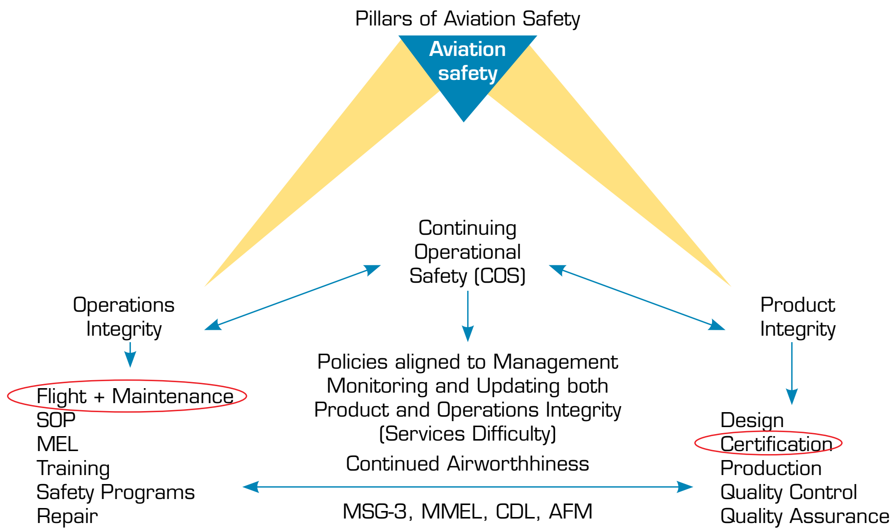


Source: Retrieved from De Andrade (2018).

Figure 1. Pillars of Aviation Safety.

Regarding transport category rotorcraft performance, the certification requirements are set out into FAA Part 29 (Airworthiness Standards: Transport Category Rotorcraft), while the operations requirements are set out into ICAO Annex 6 Part III, not being fully adopted in the U.S., which declared differences to operations in Performance Classes (Veras Neto 2021).

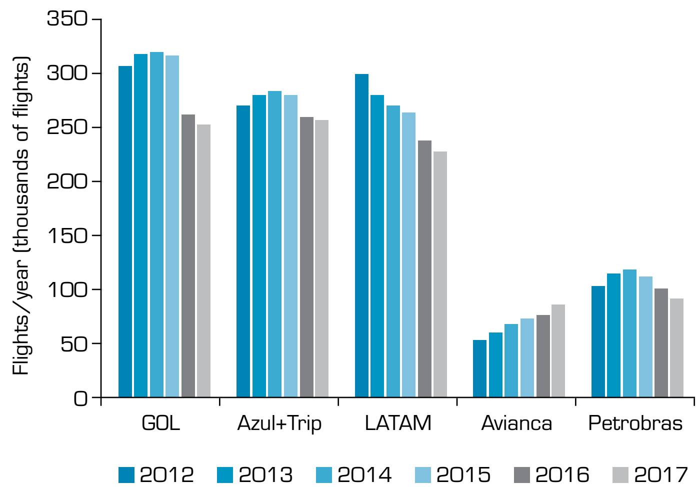
As for any aircraft, harmonious relationship between product integrity and operations integrity is also required for helicopters, which are essential for supporting offshore oil and gas activities worldwide (Nascimento *et al*. 2012). According to the International Association of Oil & Gas Producers (IOGP), an annual average of more than 418,000 flight hours were registered from 2015 to 2019 across its members, accounting for transportation of over 4,5 million passengers in 2019 (Table 1).

Table 1. Hours flown and passengers in international offshore aviation.

Year	Hours Flown IOGP*	Passengers IOGP	Hours Flown Petrobras**	Passengers Petrobras
2019	409,669	4,521,006	69,324	880,960
2018	384,136	4,522,601	72,046	917,046
2017	391,543	4,341,024	78,270	951,229
2016	415,599	4,552,202	96,668	1,028,009
2015	493,072	5,792,317	107,415	1,187,394
Average	418,804	4,745,830	84,745	992,928

* The annual average hours flown offshore for IOGP from 2015–2019 with Part 29/CS 29 certified helicopters represents 85.1% of total hours flown; ** Petrobras represents more than 20% of IOGP hours and passengers. The annual average hours flown offshore for Petrobras from 2015–2019 with Part 29/CS 29 certified helicopters represents 99.5% of total hours flown. Source: Adapted from Veras Neto (2021).

Helicopters are essential for the Brazilian oil and gas industry too, as they consolidate their position as a leading technology provider for ultra-deep and deep offshore oilfield production and development (Mendes *et al*. 2014). If all the flights were performed for Petrobras (Brazilian biggest oil and gas company) by a single air operator from 2012 to 2017, it would be the 4th biggest commercial airline in Brazil (each flight corresponding to one take-off and landing, Fig. 2). As most operations involve workers' transportation, disruptions can lead to discontinuities in oil and gas production flows, with potentially severe social, economic and political impacts (Nascimento *et al*. 2012).



Source: Retrieved from Hermeto *et al.* (2019).

Figure 2. Annual flights by Brazilian airlines and Petrobras' offshore flights.

Petrobras' logistical system is composed by eleven air bases distributed along the Brazilian coast, 50 helicopters and about 150 maritime units. Therefore, seeking ways to improve efficiency in the use of contracted aircrafts is imperative, maximizing their use without neglecting offshore flight rules, crew fatigue regulation, origin and destination airports operational restrictions and capacity limits for each aircraft (Heringer 2020).

Previous research on helicopter offshore flights were mostly focused in their operations (Clark *et al.* 2006; Nascimento *et al.* 2012), accident statistics and analysis (CAA 2014; Herrera *et al.* 2010; Nascimento *et al.* 2013), and in transport logistical improvements (Heringer 2020; Hermeto *et al.* 2019). With regards to the latter studies, they have sponsored Petrobras to direct its offshore passenger traffic to Farol de São Tomé Heliport, increasing from 25% in 2016 to 42% in 2020 of all Petrobras' offshore passengers (Petrobras 2021), with its consequent reduction in logistical costs due to proximity from Farol de São Tomé Heliport to Campos Basin offshore oil fields.

Despite the key role of certification requirements for the safe operation of rotorcraft, both in Brazil and indeed worldwide, there is a stark void of rigorous discussions in literature comparing helicopter certification performance requirements (i.e., FAA Part 29) versus operational performance requirements (i.e., ICAO Annex 6 Part III). As FAA Part 29/EASA CS29 certified helicopters account for over 85% worldwide and 99% in Brazilian offshore operations (Table 1), the focus of this paper is on comparing certification versus operation performance requirements of transport category rotorcraft.

Worldwide, a typical offshore flight consists of 5 parts: 1. One onshore take-off (airport or ground helipad); 2. A substantial part of the flight over the sea; 3. One or more elevated helidecks landings/take-offs offshore (oil rigs); 4. A flight over the sea back to an onshore base; 5. One onshore landing (airport or ground helipad). This means that at least 50% of all take-offs and landings occur at oil rigs' helidecks. Surprisingly, however, most of the helicopters used in such operations worldwide are certified to FAA Part 29/EASA CS29 but are not certified to FAR/CS 29, §29.60 (elevated heliport – Category A). The intended safety protection (i.e., aviation safety) remains, therefore, possibly unassured (Table 2).

This is particularly the case with the heaviest helicopters in Brazilian offshore operations, i.e., Sikorsky S92A and Airbus H225. The elevated helipad/helideck procedures stated in their rotorcraft flight manuals (RFMs) request the needs for approvals from the State of Operator's Aviation Authority (Sikorsky RFM S92A, Part 2, Section III, p. III-1-50; and Airbus RFM H225, Part 2, Section 9, APP.9.0.1.A1, p. 1). Curiously, the type certificate data sheets of such helicopters do not mention the lack of certification to FAR/CS 29, §29.60, arguably because, in order to be certified in Category A, only demonstrations of clear area take-off and landings capabilities (which are equivalent to those for an airport's runway environment) are required (Veras Neto 2021).

Table 2. FAA Part 29/EASA CS29 certified helicopters in Category A take-off/landings.

Rotorcraft	Clear Area	Ground Helipad	Elevated Helipad/ Helideck
Sikorsky			
S76A up to S76C	√	X	X
S76C+ and S76C++	√	X	X*
S76D	√	√	X*
S92A	√	√	X*
Airbus Helicopters			
H155	√	√	√
H175	√	√	√
H225	√	√	X**
Leonardo			
AW139	√	√	√
AW189	√	√	√

Information based in rotorcrafts' flight manuals (RFM); * Published procedures, but NOT certified or approved by FAA; ** Published procedures, but NOT certified or approved by EASA. Source: Retrieved from Veras Neto (2021).

Problem Statement

Due to lack in literature, the extent to which certification and operation performance requirements overlap, complement or contradict each other (and, thereby, are an efficient set of regulations in assuring safety) is currently unknown. Anecdotally and from experience, the relationship between certification and operation requirements for transport category rotorcraft is known to be convoluted, of difficult interpretation and shrouded in unspecified regulatory politics.

Therefore, this paper will explore possible current regulatory deficiencies by addressing the following research question: Is it possible, and desirable, to apply the entirety of transport category rotorcraft certification performance requirements to day-by-day operations?

METHODOLOGY

Research is defined as a rational and systematic procedure that aims to provide answers to problems, when there is not enough information or when the available information is in such a state of disorder that it cannot be adequately related to the problem. In this context, exploratory research aims to improve familiarity with the problem, in order to make it clearer or to build hypotheses using, for example, data collection that involves documentary and bibliographic survey (Gil 2017).

As per the nature of data, the qualitative research distinction from quantitative is based, mainly, in the adoption of an interpretative approach, where the world and society must be understood from the perspective of those who experience it. Additionally, research is of an applied nature when it aims to produce knowledge for practical application and focused in solving specific problems (Gil 2017).

This paper aims to critically peruse through historical documentation of both certification and operation of rotorcraft issued by ICAO and FAA and, in doing so, enhance understanding of the overlaps and complementarity (or otherwise) of certification and operational performance requirements for transport category rotorcraft. In this intent, the research methodology used in present paper is qualified as exploratory, qualitative and of applied nature.

RESULTS AND DISCUSSION

Fundamentals of Airworthiness and Operation: ICAO versus FAA

The bases for airworthiness into ICAO are stablished in its Annex 8 – Airworthiness of Aircraft, which states:

> The objective of international airworthiness standards is to define, for application by the competent national authorities, the minimum level of airworthiness constituting the international basis for the recognition by States, under Article 33 of the Convention, of certificates of airworthiness for the purpose of the flight of aircraft of other States into or over their territories, thereby achieving, among other things, protection of other aircraft, third parties and property (ICAO 2018c, p. xix).

Regarding aircraft operations, ICAO's Annex 6 Part III (Operation of Aircraft – International Commercial Air Transport – Helicopters), was introduced in 1986 following the introduction of Part I (Operation of Aircraft – International Commercial Air Transport – Aeroplanes) in 1948, and Part II (Operation of Aircraft – International General Aviation – Aeroplanes) in 1968 (ICAO 2020a).

Referring to definitions for Category A, Category B and Continuing Airworthiness, ICAO's Annex 8 states (our italics):

> **Category A**. With respect to helicopters, means a multi-engine helicopter designed with engine and system isolation features specified in Part IVB of Annex 8 *and capable of* operations using take-off and landing data scheduled under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight or safe rejected take-off.
>
> **Category B.** With respect to helicopters, means a single-engine or multi-engine helicopter which does not meet Category A standards. Category B helicopters have no guaranteed capability to continue safe flight in the event of an engine failure, and a forced landing is assumed.
>
> **Continuing airworthiness.** The set of processes by which an aircraft, engine, propeller or part complies with the applicable airworthiness requirements and remains in a condition for safe operation throughout its operating life. (ICAO 2018c, p. I-1)

The "…and capable of…" term highlighted in ICAO Category A definition is a remarkable difference to FAA definition of Category A, and the greatest source of discrepancies found between the two biggest airworthiness certification authorities: the European Union Aviation Safety Agency (EASA) and FAA. While the EASA applies the integrity of ICAO's definitions, the FAA applies the definitions of Part 1 of Title 14 – Aeronautics and Space:

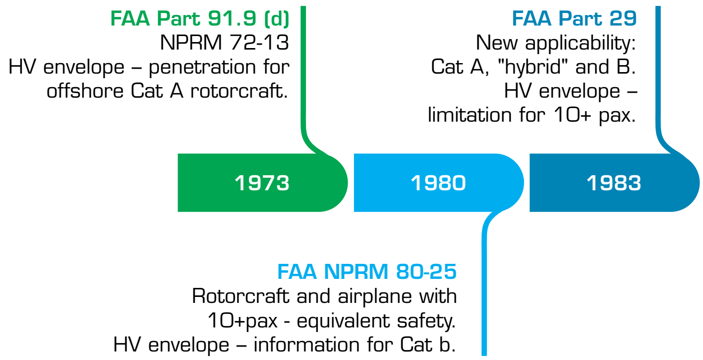
> **Category A**, with respect to transport category rotorcraft, means multiengine rotorcraft designed with engine and system isolation features specified in Part 29 *and utilizing* scheduled take-off and landing operations under a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight in the event of engine failure.
>
> **Category B**, with respect to transport category rotorcraft, means single-engine or multiengine rotorcraft which do not fully meet all Category A standards. Category B rotorcraft have no guaranteed stay-up ability in the event of engine failure and unscheduled landing is assumed (FAA 2020, p. 3, our italics).

For FAA, the term "…and utilizing…" into Category A definition restricts the operations on the bases of the certification, with operational regulations not allowing exemptions to helicopter certification operating limitations beyond the one existent into FAA Part 91, § 91.9 (d)—i.e., penetration of height-velocity (HV) envelope over water in offshore elevated helidecks' take-off/landings (FAA 1973).

Although for Category A the term "…and capable of…" as per ICAO, and the term "…and utilizing…" as per FAA are, in principle, only certification terms, their reflection into helicopter real operations is remarkable: for ICAO, once certification reflects only a "capability", the helicopter operations must be conducted under the basis of a Code of Performance that could allow exemptions to certification operating limitations, based in a risk assessments; for FAA, a helicopter demonstrates its operational capability during certification and must be operated in accordance with certification parameters—exemptions as per Part 91, §§ 91.9(a) or (d) (FAA 1973).

Certification versus Operation: Timeline History

Once understood the main conflict between ICAO and FAA regarding certification and operation, the authors will now perform a detailed comparison between certification and operations performance requirements through a historical timeline, in order to provide a full description of real problems involved in rotorcraft certification versus operation (Fig. 3).



Source: Adapted from Veras Neto (2021).

Figure 3. Timeline of performance regulation between 1973 and 1983.

In 1973, FAA approved the amendment proposed by Notice of Proposed Rulemaking (NPRM) 72-13, including in an operational rule (Part 91, §91.31, posteriorly renumbered to §91.9 (d)), the possibility to make transient flights over water through the prohibited range of HV envelope during offshore helideck operations (FAA 1972; 1973). This was the first time that an operational rule corrupted a certification in order make commercially viable the offshore operations, and this corruption remains after almost 50 years with no ending date in sight.

Up to the 1980s, there were basically two categories in place for rotorcraft: a "Normal Category" for relatively small rotorcraft (limited to 6,000 lb maximum weight; revised to 7,000 lb in 1999); and a "Transport Category" subdivided in Categories A and B, applicable to large rotorcraft intended for use in air carrier service.

In Category A, rotorcraft has proven a safe flight capability with an engine failure at any point during flightpath. In Category B, there is no continued takeoff, continued flight, or destination landing capability in the eventuality of an engine failure. Operationally, a forced landing is assumed at any point of flight if an engine fails in a Category B rotorcraft, and the pilot will have to do the best he or she can under the circumstances.

Both categories A and B included the height-velocity envelope (the famous dead's man curve) as an operating limitation in order to assure a high level of safety for transportation of passengers. However, the incorporation of HV envelope as a Category B limitation ended up inhibiting various utility applications for large helicopters.

In 1980, FAA published the NPRM 80-25, with the intention to add new rotorcraft airworthiness standards and revise the applicability sections of Parts 27 and 29, providing additional protection for rotorcraft carrying 10 or more passengers. The idea was to have passenger-carrying airplanes and helicopters being accepted by the traveling public on an equal basis, i.e., providing equivalent continued flight performance capability (FAA 1980).

FAA NPRM 80-25 proposed, in its item 3, the following for Parts 27 and 29:

> Revisions to the applicability sections of Parts 27 and 29 to limit the number of passengers for which normal category and category B rotorcraft may be certificated, to require category A certification for any rotorcraft design to carry 10 or more passengers, to remove the 20,000-pound weight limit on category B rotorcraft, and to remove the height-velocity operating limitation from category B rotorcraft. (FAA 1980, p. 83425)

In 1983 and unchanged till now, due to a lot of pressure from market (particularly Original Equipment Manufacturers [OEMs]) and high estimated economic impact, FAA (1983) reformulated the applicability proposed by NPRM 80-25 and provided alleviation for rotorcraft carrying 10 or more passengers and maximum take-off weight (MTOW) up to 20,000 lb, revising the applicability of the Part 27 (nine passengers limit) and Part 29 (Amdt. 29-21), which required rotorcraft with MTOW over 6,000 lb (revised to 7,000 lb in 1999) to be Part 29 certified in accordance with three different levels of certification requirements regarding performance:

1. Category A: rotorcraft with a maximum weight greater than 20,000 pounds and 10 or more passenger seats;
2. Category B, provided the Category A requirements of §§29.67(a)(2), 29.87, 29.1517 are met: rotorcraft with a maximum weight of 20,000 pounds or less but with 10 or more passenger seats; and
3. Category B: rotorcraft with nine or less passenger seats, regardless the maximum weight.

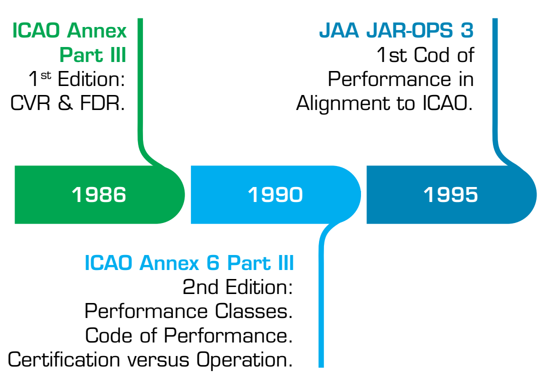
For the authors, in practical terms, three certification levels were created regarding performance under FAA Part 29: one pure Category A (item 1), one pure Category B (item 3), and one *hybrid* Category (item 2). In the *hybrid* Category, the rotorcraft must comply with pure Category B and, additionally, only two performance requirements of Category A (i.e., §29.67(a)(2) – 2nd segment of Category A take-off one engine inoperative (OEI) from 200 to 1,000 ft above the surface, with rate of climb of 150 ft/min at *Vy*; §§29.87 and 29.1517 – forbidden HV envelope, where any combination of height and forward velocity, including hover, within which it is not possible to make a safe landing following power failure of the critical engine).

In contrast to OEMs' pressure that culminates in alleviation of certification performance requirements for rotorcraft carrying 10 or more passengers and MTOW up to 20,000 lb, no single helicopter type post new applicability of Part 29 (Amdt. 29-21) has been certified purely under §29.1(e) – i.e., the *hybrid* Category. Therefore, one understands that OEMs' focus was not on certification itself, but in its future impact into operations performance requirements, which has been proved significant (Veras Neto 2021).

In 1986, ICAO published the 1st Edition of Annex 6 Part III, only established in its first complete form in 1990, as the 2nd Edition, stating that: "Helicopters shall be operated in accordance with a code of performance established by the State of the Operator, in compliance with the applicable Standards of this chapter" (ICAO 1990, p. 13). Here starts the saga of rotorcraft's certification performance versus operations performance requirements.

In formulating the Annex 6 Part III, ICAO adopted the principle, applicable to airplanes in Annex 6 Part I, of engine failure accountability or safe forced landing (SFL) (ICAO 2020b). This was included as one of the objectives of Performance Classes 2 and 3, as the requirement to perform an SFL should an engine fail at a critical time, which is defined as an unavoidable ditching or landing with a reasonable expectancy of no injuries to persons in the aircraft or on the surface of water or ground, even though the aircraft may incur in extensive damage (ICAO 2018a).

The ICAO also stablishes a linkage between airworthiness and operations, of which harmonization is one of goals for aching aviation safety, as stated in Annex 6, Part I: "The level of airworthiness of an aircraft is, however, not fully defined by the application of the airworthiness Standards of Annex 8, but also requires the application of those Standards in the present Annex that are complementary to them" (ICAO 2018a, p. xxi). Even though the Annex 6 Part III does not make nominally the same relation between its performance requirements and those stated in Annex 8, it is assumed the same relation is valid (ICAO 2020b) Fig.4).



Source: Adapted from Veras Neto (2021).

Figure 4. Timeline of performance regulation between 1986 and 1995.

In relation to airplanes, ICAO Annex 8 does not predict any possibility of exceeding operating limitations: "… assuming that the aeroplane is operated within the limitations specified. The limitations shall include a margin of safety to render the likelihood of accidents arising therefrom extremely remote" (ICAO 2018c, p. IIIB-1-1). In contrast, regarding helicopter operating limitations, Annex 8 states: "… compliance with the Standards of this part shall be established assuming that the helicopter is operated within the limitations specified. The *safety implications of exceeding these operating limits shall be considered*" (ICAO 2018c, p. IVB-1-1, our italics). In practice, this can be perceived as a previous deliberate intention of exceeding operating limitations during rotorcraft operations.

The remarkable ICAO's difference in views between airplane operations and helicopter operations coupled with the "be considered" expression in Annex 8, has been used since the first code produced in compliance with Annex 6 Part III, i.e., JAR-OPS 3 in Europe. In 1995, the Joint Aviation Authorities (JAA), currently European Union Aviation Safety Agency (EASA), published the JAR-OPS 3 (Commercial Air Transportation – Helicopters), further transposed into EASA Air Operations (EU 965/2012), as the first helicopter operation requirements in compliance with ICAO Annex 6 Part III, but quickly observed the needs to reflect operations with an exposure time to catastrophic events during take-off or landing, based on risk assessments.

Certification is factory gate-in, and its alignments between Europe and the USA ensures worldwide marketing access to the OEMs. However, slight terminology differences in certification have historically produced huge differences in operation, which is factory gate-out, providing commercial operations' viability for some suboptimal designed rotorcraft, while assuring OEMs' profitability and delays to necessary (safety-wise) product improvement.

For ICAO, Categories A and B are type of operations referred in certification code only (Part 29/ CS 29), where prescriptive parameters are clearly established for Category A but not so clear for Category B. Therefore, the "...and capable of..." term in ICAO's Category A definition would allow operations to be conducted under the bases of a Code of Performance with exemptions to certification operating limitations, once associated safety implications of it would have been previously considered by means of risk assessments, approved by the State of operator (Veras Neto 2021).

ICAO's statements should be looked with parsimony, once aircraft's certification may be described as a tool for limiting the risk and uncertainty of safe operation. Certification also may be expressed as instrument for gaining confidence that the operation will be safe (Gnot 2009). For the authors, there is an intrinsic relationship between certification and operation procedures, not being reasonable or justifiable to simply disregard the certification parameters.

Particularly, in countries that have not produced their own codes of performance, the certification procedures presented in the RFM are the unique references available for the pilots in order to operate the rotorcraft safely. Therefore, ICAO's interpretation that helicopters are certified based on the airworthiness code, but are operated on the bases of a Code of Performance that may allow the neglect of certification parameters that should be enforced seems, ultimately, inadequate.

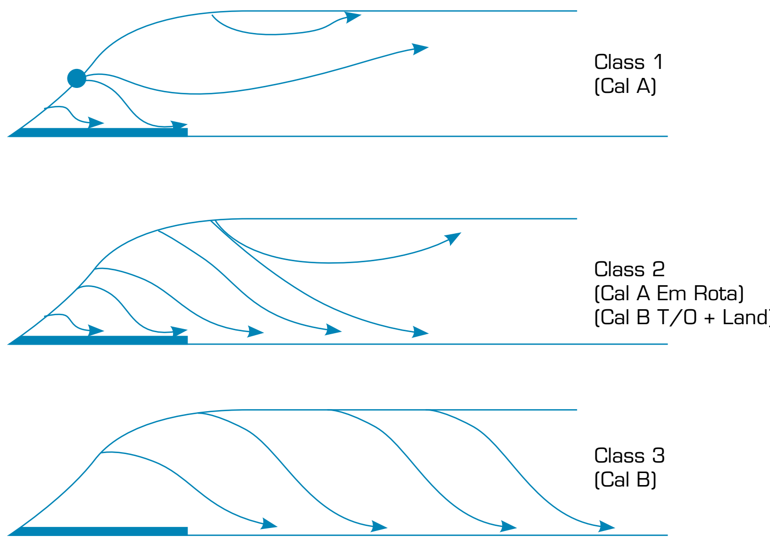
For the authors, ICAO's *capability* concept would be valid only when the certification achieved is not required by regulation. For example, a Part/CS-27 certified helicopter which has been chosen by OEM to be also certified in Category A (in accordance with Appendix C – Part/CS-27). Once not mandated by certification regulation for helicopters up to 9 passenger seats, the Category A certification is a marketing advantage, not a certification requirement. Therefore, if the State of Operator develop a Code of Performance, that demonstrated additional capacity could be neglected.

For the authors, reminding the beginnings of air operations worldwide, it is not feasible to assume that the test flights were performed as a mere curiosity (Fig. 5). The flight test campaign is performed to collect data, which analyzes verifies if the requirements have been met. Such requirements are written based on the assumed regular operation of the aircraft. However, it is not reasonable to believe the test flights and certification would reflect 100% of the possibilities faced in operational environment for which an aircraft has been designed for. Though, it is necessary to consider some flexibility, particularly regarding the use of helicopters, but not to the extent of neglecting operating limitations.

Source: Retrieved from Alberto... (2004).

Figure 5. 14 Bis airplane test flight and operational flight at Bagatelle Field, 1906.

In terms of engine failure accountability (Fig. 6), the following relation is valid: Performance Class 1 (PC1) correlates to that of Category A; engine-failure risk-profile of Performance Class 2 (PC2) correlates with that of Part 29 helicopter with a limiting mass of 20,000 lb and 10 or more passenger seats (the *hybrid* Category); and engine-failure risk-profile of Performance Class 3 (PC3) correlates with that of Category B.



Source: Retrieved from Veras Neto (2021).

Figure 6. Operational Classes versus Certification Categories.

Regarding passenger carriage limits within the performance classes, the following relation is applied: PC1, unlimited; PC2, 19 or fewer passengers; and PC3, nine or fewer passengers. Performance classes also accounts for obstacle clearances in the flight path (ICAO 2020b).

ICAO (2020b) considers that: helicopter types certificated in Category A are capable of operations in PC1, PC2 or PC3; helicopter types certificated in Category B, in accordance with Part/CS 29.1(e), are capable of operations in PC2 or PC3; helicopter types certificated in accordance with the performance provisions in Part/CS 27 or in Category B, under the provisions of Part/CS 29.1(d) and (f), are capable of operations in PC3.

Performance Class 2 arises from the fact that not all multiengine rotorcraft has the engine failure capability for safe rejected take-off, or continued safe flight, following an engine failure within certain low speed flight phases. It permits taking advantage from all engine operatives procedures for a short period during take-off and landing (while retaining engine failure accountability in the climb, descent and cruise) and thus increase MTOW when the surface conditions are not adequate for rejection but are suitable for SFL.

The operational outcome of this is having a helicopter carrying 10 or more passengers and MTOW over 20,000 lb, certified mandatorily in Category A by Part 29, §29.1(c), but operating in PC2 (with and, in some cases, without a SFL capability – exposure) instead of being subjected to engine failure accountability assurances provided by Category A procedures during take-off and landings.

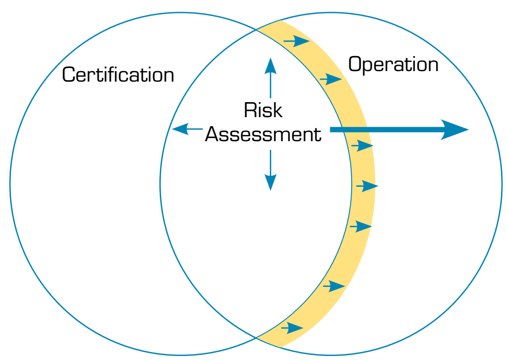
As an example, the helicopter Sikorsky S92A (similar reductions in payload also applies to Airbus H225) taking-off from a ground helipad at sea level and 30 °C, operating in PC2, has a MTOW of 26,500 lb (S92A RFM, Part 1, Section IV, Figs. 4–8 and 4–9, without rejected and continued takeoff distance restrictions). However, the MTOW in Category A is reduced to 23,640 lb (S92A RFM, Part 1, Section IV, Fig. 4–17, ground level helipad) – i.e., 2,860 lb or 1,300 kg of payload reduction (Sikorsky 2012).

This payload reduction reality is claimed to be commercially feasible for VIP flights, but not for oil and gas industry ferry ones, thus requiring the use of PC2 (operations) instead of Category A (certification) during day-by-day operations. Controversially, the oil and gas industry is exactly the one that would economically be able to push the OEMs in providing better performance designed helicopters.

Additionally, if the flight in previous example is also heading offshore for elevated helideck operations, the problem is compound, once Sikorsky S92A (same for Airbus H225) is not certified under Part/CS 29, §29.60. It means that 100% of take-off and landings (onshore, to/from ground helipad; and offshore, from/to elevated helideck) of those helicopters would not be covered by the safety assurances provide by certification performance requirements. Surprisingly, Sikorsky S92A and Airbus H225 are the heaviest helicopters used for offshore operations in western world, both carrying up to 19 passengers and with a MTOW over 20,000 lb.

In summary, to assure commercial viability, it is pushed to pilots and air operators the responsibility to manage poor certification performance of some helicopters (e.g., commercially unfeasible MTOW of Category A for helipad, due to severe payload reduction) or poor aviation infrastructure (obstructions in the flight path or prevailing cross wind). In the Authors' opinion, changing the standards to create feasible constraints to perpetuate current operations status are against the original regulators' intents expressed at FAA NPRM 80-25 (FAA 1980).

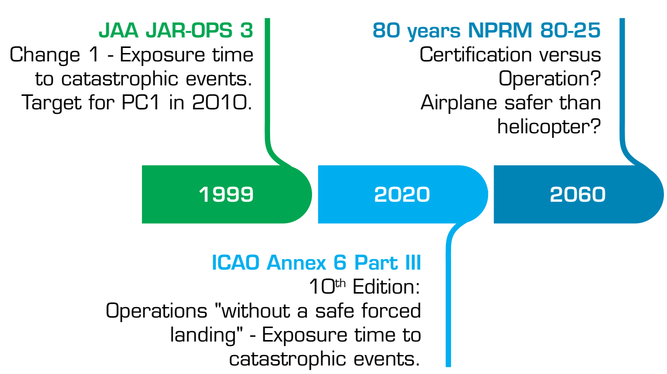
From the authorities' side (Fig. 7), ICAO/EASA's view of certification performance boils down to a mere capability demonstration. Therefore, a Code of Performance produced by the State of Operator is called for assuring the continuity of operations, managing poor operational performance of some helicopters through risk assessments. FAA's view also allows for increased payload over Category A certification performance, but through exemptions based in Part 91.9 (a) (FAA 2015; 2016).



Source: Retrieved from Veras Neto (2021).

Figure 7. Risk assessment allowing operational flexibilization of certification.

In 1999, exposure time was introduced in Europe through JAR-OPS 3 Change 1, allowing for catastrophic events during 9 seconds for twins during every take-off or landing (residual risk), based on the assumption that helicopters' turbine engines would have failure rates around 1:100,000 per flying hours, allowing for an agreed safety target of 5×10^{-8} per event (EASA 2019, p. 756). The time limit for operations being conducted with an exposure time to/from helidecks or elevated heliports was set to December 31st, 2009 (JAA 1999) (Fig. 8).



Source: Adapted from Veras Neto (2021).

Figure 8. Timeline of performance regulation between 1999 and 2060.

At this time, it is important to differentiate the following terms: normal landing; rejected takeoff; SFL; and exposure. In a normal landing, impact loads up to 1.5 times the MTOW are accepted, consistent with the landing inertia load factor of shock absorption test (Part 29, §29.723) and limit drop test (Part 29, §29.725). In a rejected takeoff following and engine failure up to takeoff decision point (TDP), impact loads up to 2.5 times the MTOW are accepted, which is consistent with an emergency landing and with the reserve energy absorption capacity of the landing gear in the shock absorption test (Part 29, §29.723) and reserve energy absorption drop test (Part 29, §29.727).

SFL (applied for operations in PC2 or PC3, only) following an engine failure, as previously defined, presents a *major* safety risk severity category. Differently, in operations with exposure, an engine failure will lead to an event with fatal injury to an occupant, or multiple fatalities, or loss of rotorcraft, therefore with a safety risk severity category of *hazardous* or *catastrophic* (ICAO 2020b).

Operations with exposure alleviates the certification requirement for the provision of SFL, including: the surface conditions of the operating site, obstacles below 200 ft (60 m) in the take-off flight path, and flight inside the HV envelope (for take-off and landing). Additionally, when operating over elevated heliports and helidecks, exposure covers a deck-edge strike after engine failures early in the take-off or late in the landing, or forced landing with obstacles on the surface (or hostile water conditions) below the elevated heliport/helideck.

From 1999 to 2007, for several reasons (e.g., the deck size and the helideck environment—including obstacles and wind vectors), it was evaluated that operations in PC1 would be not technically feasible or economically justifiable by projected JAA deadline (December 31st, 2009). The European OEMs collected great amount of data and convinced the aviation authority to disregard PC1 target date and perpetuate operations with exposure in North Sea offshore operations.

The logic used by OEMs to convince the European Authority is called *reverse* as low as reasonably practicable (ALARP) (NOPSEMA 2020), which tried and succeeded in showing, through cost benefit analysis and quantitative risk assessment, that moving to a less protected situation would meet the legal requirement to reduce risks to a level that was ALARP, arguing that the increase in risk would be more than balanced by gains in reduced operational costs.

One should notice that *reverse* ALARP is a way of not applying mitigation measures available in market using questionable statistical justifications, mainly with the intents to *demonstrate* that doing nothing is ALARP. In practice, in the context of present work, it is to use risk assessment (operational tool) to solve the problem of poor performance rotorcraft design (certification), what would be acceptable for short period and in very specific circumstances but not as a long-term decision (Veras Neto 2021).

JAA (2007) published the Amendment 5 to JAR-OPS 3, suppressing the exposure ending target date and consequent requirement for PC1 in offshore operations, and introducing the expression "takes into account" in the application of JAR-OPS 3.520/3.535 take-off and landings mass calculations (JAA 2007, p. 1-H-1–1-H-2). At this point, the short-term for exposure became long-term.

Up to 9th Edition, ICAO Annex 6 Part III, in its item 3.1.2 contents, regarding PC2 and PC3, presented:

In conditions where the safe continuation of flight is not ensured in the event of a critical engine failure, helicopter operations shall be conducted in conditions of weather and light, and over such routes and diversions, that *permit a safe forced landing to be executed*. (ICAO 2018b, p. II-3-1, our italics)

The safe landing and SFL concepts are aligned with FAR/CS 29 requirements for Category A and B rotorcraft, respectively.

In 2020, the 10th Edition of Annex 6 Part III, innovated presenting the possibility for *exposure* as stated into new item 3.1.3:

> Notwithstanding the provisions of 3.1.2, the State of the Operator may, based on the result of a risk assessment, allow for variations *without a safe forced landing* to be included in the Code of Performance established in accordance with the provisions of 3.1.1. (ICAO 2020a, p. II-3-1, our italics)

This has killed the 40 year-long *hope* of having engine failure accountability for 10 or more carrying passenger's rotorcraft, and finally assure equivalent levels of safety between rotorcraft and airplane through certification performance requirements.

The gap between certification and the reality of operations reflects the urgent need to bring certification back to the real world. For the authors, it is not reasonable to accept that certification would reflect only a *capability*, as stated by ICAO, instead of reflecting the operations reality. Fortunately, the new helicopter developments in market (e.g., Leonardo AW139 and Airbus H175) are effectively certified in Category A clear area, ground helipad and elevated helipad, with a payload reduction between clear area versus ground helipad that allows for extinguishing the alleged *commercial viability* that led to operations in PC2 with *exposure* (Table 3).

Table 3. FAA Part 29/EASA CS29 certified helicopters in Category A: payload reduction of clear area versus ground helipad.

Rotorcraft	Clear Area	Ground Helipad	Payload reduction
		Sikorsky	
S76D	11,875lb	11,310lb	565lb/ 257kg
S92A	26,500lb	23,640lb	2,860lb/ 1,300kg
		Airbus Helicopters	
H175B	7,500kg	7,300kg	200kg
H225	10,500kg	8,950kg	1,550kg
		Leonardo	
AW139	6,800kg	6,430kg	370kg
AW189	8,300kg	7,858kg	442kg

Data is based in rotorcrafts' flight manuals (RFMs) for 0ft PA and 30 °C; S76D: RFM Nr S76D-RFM-000 Rev. 9, Part 1, Section I, Figures 1-6 and 1-7; S92A: RFM Nr S92A-RFM 006 Rev. 13, Part 1, Section IV, Figures 4-9 and 4-17; H175B: RFM Nr EASA.R.150, Vol. 1, SUP1, Page 1 of 18-22 (MTOW reduction to 7,500 kg); Figs. 10c and 31 (TDP 50 ft); H225: RFM N. 7902, Vol 1, SUP1.1, engine Makila 2A1, Figures 7a and 8a; AW139: RFM Nr 139G0290X002, Vol 1, Rev. 26, SUP50, Figures 4-1 and 4-4 (TDP 35ft); AW189: RFM Nr.189G0290X002, Vol 1, Rev. 4, Section V, Supplement 4, Figures S4B-6 and S4A-6. Source: Retrieved from Veras Neto (2021).

Although an updating in rotorcraft certification regulation possibly take place in the next few years to better reflect the reality of operations, it is important to highlight there will be a great amount of rotorcraft still certified in the old regulation that have to be safely operated. Once actual certification regulation does not cover a significant part of operations, an operational regulation demanding risk assessments and setting parameters for approvals is the best course of action to be taken. Therefore, the authors understand the Code of Performance will be need for a certain period, preferable with a dead line in place.

CONCLUSION

It is very common to hear into aviation forums and congresses, and mainly into the operational field, that the modern transport category helicopters produced into 21st century provide the same safety levels than their fixed-wing counterparts. For the authors this is not true. First, because the helicopters carrying 10 or more passengers but up to MTOW of 20,000 lb are not required to be certified into Category A by certification regulation (FAR/CS 29, §29.1(e)). Second, although effectively certified into Category A, they are not operated into the bases of certification but into the bases of an operational code, that usually corrupts the certification operating limitations and procedures in name of commercial viability of suboptimal helicopters design.

This fact is even more remarkable when considering helicopters with MTOW over 20,000 lb and carrying 10 or more passengers, used largely in oil and gas industry offshore operations, whose procedures for vertical take-off and landings over elevated helidecks are not certified into FAR/CS 29, §29.60, therefore requiring approvals from the State of Operator, which usually do not have the necessary certification expertise in order to provide such authorizations and ensure the safety of those operations, based in risk assessments.

Answering the research question of the present paper (is it possible, and desirable, to apply the entirety of transport category rotorcraft certification performance requirements to day-by-day operations?), the authors understand that yes. The reason for being possible is because the latest helicopter designs have proved a performance much superior than older ones. The reason for being desirable, it is because achieving single engine failure accountability is a gap in safety accounting for over 40 years between rotorcraft versus airplanes, carrying 10 or more passengers.

AUTHORS' CONTRIBUTION

Conceptualization: Veras Neto CR; **Validation:** Veras Neto CR; **Formal analysis:** Veras Neto CR; **Investigation:** Veras Neto CR; **Data Curation:** Veras Neto CR; **Writing – Original Draft:** Veras Neto CR; **Writing – Review & Editing:** Veras Neto CR; **Visualization:** Veras Neto CR; **Supervision:** de Andrade D; **Project administration:** Veras Neto CR.

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