


Evaluation of the Human Harnesses used by Tactical Flight Officers in Brazilian Public Air Units

André Ricardo de Almeida Vilela¹ , Donizeti de Andrade² , Marcelo Guerrante Guimarães^{3,*} 

1. Departamento de Polícia Federal  – Diretoria Executiva – Comando de Aviação – Brasília/DF, Brazil. **2.** Departamento de Ciência e Tecnologia Aeroespacial  – Instituto Tecnológico de Aeronáutica – Divisão de Engenharia Aeronáutica – São José dos Campos/SP, Brazil. **3.** Helisul Aviação – Departamento de Operações – Curitiba/PR – Brazil.

*Correspondence author: vilela.arav@gmail.com

ABSTRACT

This work evaluates the normative and legal compliance related to the human harnesses used by tactical flight officers in the institutional missions conducted by the Brazilian Public Air Units (UAPs), regulated by the Brazilian Civil Aviation Regulation (RBAC) no. 90. The study bases its analysis on the identification of regulatory obstructions that limit the performance of the Brazilian State, from the operational and aeronautical product certification standpoints, as well as on the demonstration of legal risks to the current operational context adopted by the units. The use of inappropriate human harnesses has shown to be a contributing factor to aviation occurrences and fatalities in Brazil. This research delivers a regulatory alternative with a view to greater operational flexibility, legal safeguards and increased safety for the UAPs and entities that employ air transportation as a tool for their institutional activities.

Keywords: Human harnesses; Aeronautical product certification; Public air units; Aircraft operators; Regulatory issue.

INTRODUCTION

Article 144 of the 1988 Constitution of the Federative Republic of Brazil establishes that public security is the duty of the State, the right and responsibility of all and is exercised by the public security agencies to preserve public order and the safety of people and national heritage.

According to Botelho (2007), due to the size and geographical diversity of the Brazilian State, the public security agencies need air modal to reach their constitutional obligations and to increase the State's response capacity.

According to data published by the National Civil Aviation Agency (ANAC 2017), Brazil already had more than 230 aircraft in operation in the various Brazilian public security agencies, as well as formal developed studies related to the need for regulatory interventions of the State in public security operations to maintain operational safety.

As a reflex and differently from the USA (FAA) and the European Union (EASA), on April 12, 2019, Brazil published the first regulatory framework for public aviation through the Brazilian Civil Aviation Regulation no. 90 (RBAC 90), after publishing a regulatory impact analysis (ANAC 2019a). Briefly, this normative instrument established operational requirements, training,

Received: Jun 08, 2022 | Accepted: Aug 30, 2022

Peer Review History: Single-Blind Peer Review.

Section editor: Ana Morais



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personal protective equipment, standardization, and guidelines for the implementation of the Safety Management System to achieve the constitutional obligations of the State in a safe manner.

Despite the efforts of regulators, this research shows that the regulations in force in Brazil have been silent or have regulatory weaknesses related to the safe use of human harness (Personnel Carrying Device System) employed by tactical flight officers in operations conducted by Brazilian Public Air Units (UAPs).

The fact is that such equipment is essential for the development of the air units' missions, since it allows the tactical flight officer to move inside and outside the helicopter, in police, emergency, or surveillance operation scenarios. However, the practice of using such equipment is in apparent normative conflict and may also give rise to legal risks to the UAP managers and crew members.

In addition, data from the Brazilian Aeronautical Accidents Investigation and Prevention Agency (CENIPA) reveal that since 2010, Brazil has registered 165 aeronautical occurrences with aircraft linked to UAPs. Of this total, 6.25% were directly related to the use of Human Harness (Personnel Carrying Device System) not certified or recognized by any civil aviation authority, which culminated in two (2) fatalities in that period (CENIPA 2021).

According to their operational reality, it is believed that this research can help UAPs, managers, aircraft operators, tactical flight officers, crew members and international regulatory agencies to carry out risk management, impact analysis, and the implementation of mitigation measures resulting therefrom to reduce aeronautical occurrences and fatalities.

DEFINITIONS

Brazilian Public Air Units (UAPs)

RBAC 90 defines a UAP as the group, battalion, division, center, coordination or unit responsible for the air operations of the public administration (ANAC 2019a).

Tactical Flight Officers

Due to the nature of the operations and the increased risk exposure not found in the general aviation routine, regulated under the International Civil Aviation Organization (ICAO) annexes, ANAC establishes a specific regulation in paragraph (c), Section 90.21 of RBAC 90 about the operational crew, when in public operation (ANAC 2019a).

As standard, the operational crew is defined as the minimum crew, described in the airworthiness certificate of the aircraft, plus the personnel required for the performance of special public aviation operations. With this, the function of tactical flight officers arises in the normative.

The normative establishes a series of requirements associated with the exercise of this new function, such as a training program approved by the unit, being part of the UAPs' manuals, such as the *Standard Operating Procedures* (SOP). Such documents must be integrated with the Safety Management Systems, implemented by the units, for risk management and hazard identification.

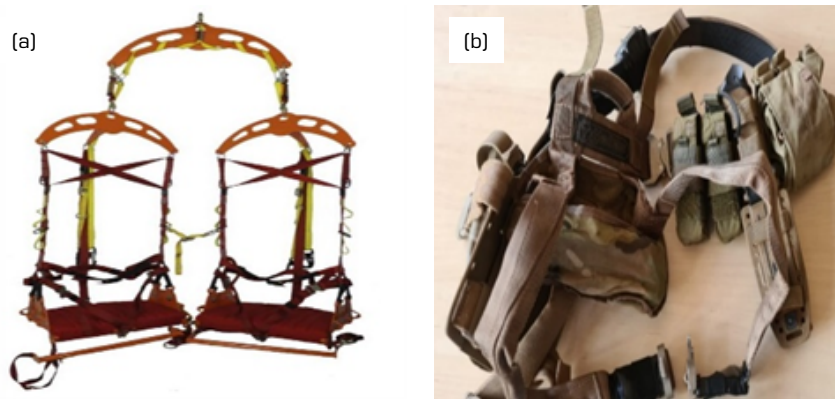
The training curriculum for tactical flight officers involves, among others, the use of personal protective equipment, the procedures for the use of safety belts and other harnesses—paragraph (d) (15), Section 90.211—; the use of onboard operational equipment, such as tactical and rescue equipment, and other special operations, such as rappel, McGuire and fast rope.

Human Harnesses

Sit harness

Known in Brazil as *baudrier*, it is a kind of safety belt. It is a device that attaches a person to a rope or to an anchor point, involving the legs and the waist.

In a complex operational environment, *baudrier* is best suited for rescues on the ground or at sea (Fig. 1a). It is different from the device indicated for firefighting, being also different from the model best suited for criminal patrol and confrontation, in which the tactical flight officer can act in support of landing in a restricted area and disembark to perform a dislocation and subsequent assault, armed with a firearm, ammunition, and handcuffs (Fig. 1b) (PMESP 2012).

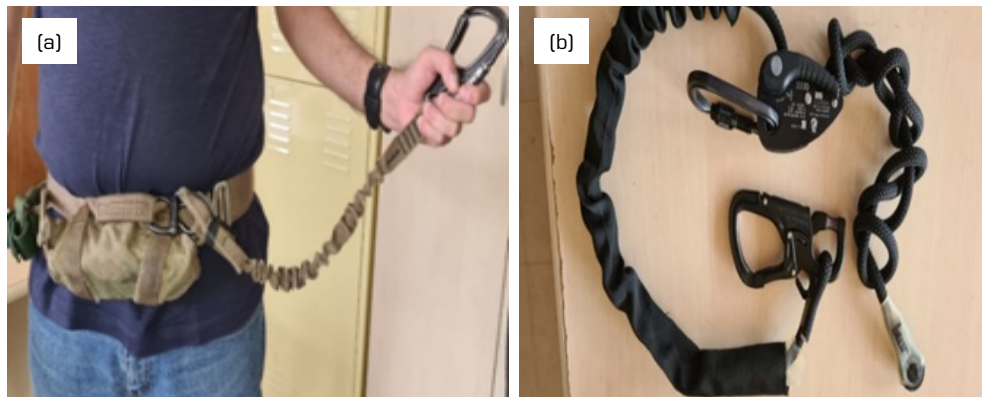


Source: (a) Air Rescue Systems (2021); (b) The authors.

Figure 1. (a) Rescue and (b) tactical *baudrier*.

Hoist Belt

Another device used in the air units, the Hoist Belt, is commonly known in Brazil as *monkey tail* (Fig. 2a). It is a device composed of a steel cable attached to a nylon belt that opens and closes quickly, which serves as anchorage for the Tactical Flight Officers. In special operations it becomes the safety belt in combination with the *baudrier* (Fig. 2b) (PF 2020).

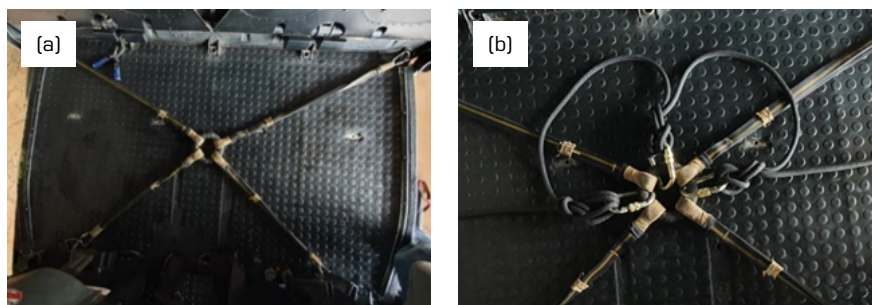


Source: The authors.

Figure 2. (a) Standard and (b) advanced *monkey tail*.

Anchorage

In other external load operations, most commonly rappel and McGuire, a device anchored to fixed points on the aircraft that are interlocked in the center of the helicopter's cabin floor is used (Fig. 3a). This anchorage is called *spider*, where the hooks and cable ties are attached (Fig. 3b) (PF 2020).



Source: The authors.

Figure 3. (a) *Spider* and (b) *spider* attachment to the cabin floor, fixing the hooks.

Belly Band

The cable that connects external cargo to the aircraft is defined as long line in human external cargo (HEC) operations. The long line is attached to the cargo hook and Belly Band. The Belly Band is known as an emergency anchor, and is typically a strap that extends through the rear cabin doors around the helicopter's cabin floor, serving as a secondary means of attachment for the external crew member (Head 2018). In the event that the cargo hook is inadvertently released, the HEC is restrained by the Belly Band (Fig. 4).



Source: Head (2018).

Figure 4. Belly Band.

METHODS

The method used in this work is the bibliographic review and the type of research is applied and qualitative, because from the studies on the use of tying devices in public air units and the normative foundations in vigor, there is a view on the weaknesses regarding regulatory aspects, aeronautical product certification and associated legal risks.

RESULTS

Aeronautical Standards References

General operating rules

According to Resolution no. 30, from May 21, 2008, RBACs are intended to establish the requirements for Brazilian Civil Aviation covering the standards and procedures recommended by ICAO: RBAC 91 is the regulation that deals specifically with the general operating requirements for civil aircraft; RBAC 133 establishes the rules for the operation of rotorcraft carrying external loads. However, this regulation does not apply to special operations of public air units covered by RBAC 90.

Aircraft Certification and Airworthiness Regulations

Certification is the systematic process, monitored and evaluated, in order to provide an adequate degree of confidence that a product, company, process or service, or even a professional, meets preestablished requirements in standards and regulations of civil aviation. Airworthiness is the operating condition in which the product performs the functions for which it was designed under flight safety conditions (ANAC 2012).

RBAC 21 is the regulation that deals with aeronautical product and article certification, and RBAC 27 defines the airworthiness requirements for rotary-wing aircraft in the normal category.

Requirements adopted abroad

Federal Aviation Administration (FAA)

The specifics of US public air units are covered by the Advisory Circular AC no. 00-1.1B Public Aircraft Operations. (FAA 2018a). The norm that defines the technical criteria for the certification of seat belts for crew members is the TSO-C114 of March 27, 1987 (FAA 1987).

Baudriers used in Brazil are recognized as personnel carrying device systems for the American regulation. The TSO-C167, dated from June 09, 2004, certifies the minimum performance standards that harnesses must meet to obtain approval and identification as equipment intended for transporting HEC (FAA 2004).

In 2017, to increase operational safety, FAA issued the Advisory Circular AC no. 133-1B – Rotorcraft External-Load Operations. In this regulation, human external load is defined as a person who, at some point of the operation, is carried out of the rotary-wing aircraft. Item 9. (c) Operating Procedures states that “Crew members must wear approved safety belts and be secured to an approved aircraft anchorage point when not seated with their safety belts fastened” (FAA 2017, p. A-6).

Belly bands are classified as portable safety devices by the Information for Operators 12015 (FAA 2012). Their use as a backup anchor does not bypass a certified load hook for HEC operations, as prescribed by the Safe Alert for Operators (SAFO) 18013 from 2018 (FAA 2018b).

FAA issues a SAFO when the document carries important safety information that may include recommended actions. Specifically, SAFO 18013 prohibits the conduct of HEC operations by part 133 operators with means of attachment not certified with the HEC requirements contained in parts 27 and 29. However, for public aircraft operators, FAA only recommends the evaluation of risks and application of appropriate mitigation measures when conducting operations with human external loads (FAA 2018b).

Civil Aviation Authority (CAA) from UK

The UK Civil Aviation Authority (CAA), like the Brazilian ANAC, has a specific regulation for police air units. This is the CAP 612 – Police Air Operations Manual (PAOM) (UK Civil Aviation Authority 2010).

CAP 612 provides in chapter 1 a transport configuration with normal seats and another for special operations (transport of specialized teams, evacuation of injured people, and the rapid evacuation of tactical flight officer in a potential danger scenario).

In Section 4 - Flight crew and police observer responsibilities (r), “All occupants of the aircraft are properly secured in a seat by safety belts prior to takeoff, subject to the exemptions allowed in Section 5,” (UK Civil Aviation Authority 2010, p. 2) in which the police observer, here understood as the tactical flight officer, must be on board.

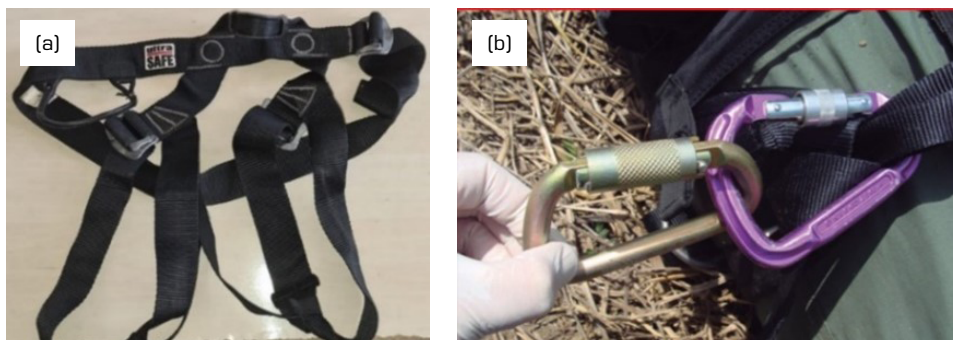
For external load operation, the PAOM uses the regulations provided in CAP 426 (UK Civil Aviation Authority 2021) “Helicopter external sling load operations,” which in a very concise way states that the installation of all winch and load hook equipment and any subsequent modifications must have an airworthiness approval appropriate for the intended function by the CAA.

Likewise, CAA also requires that nets and cables and other components to be used must have been manufactured in accordance with standards of the British entity (CAP 612, p. 205) (UK Civil Aviation Authority 2010).

Accident Records

On June 14, 2010, the tactical flight officer, while positioning himself outside the aircraft during a landing approach, suffered a fatal fall from the aircraft, registration PT-HZL, model AS 350 B2. The operation was conducted in order to identify deforestation points in the region of Guajará-Mirim, state of Rondônia.

The Final Report A - no. 084/CENIPA/2012 states in the factual information item that (our translation) “the abdominal belt (baudrier) used by the crew member at the time of the accident was not an approved aeronautical product” (CENIPA 2012, p. 8) even though it was resistant and safe (Fig. 6).



Source: (a) The authors; (b) CENIPA (2012).

Figure 5. (a) Identical *baudrier* and (b) victim.

According to the investigation, at the time of the accident, the crew member “did not use the safety belt that he had in his cabin seat, and that he only used a tape in which he tied a knot and attached it to the lap belt through hooks” and that “he used, at the time of the accident, a safety abdominal belt that was anchored, through a tape passed through a ring on the floor of the helicopter.” In addition, the tape was tied by a knot to the belt and “as the knot was not correctly adjusted, the crew member’s weight was enough to loosen it, causing him to fall” (CENIPA 2012, p. 14, our translation). As a conclusion, the investigators testify that the aircrew operator’s anchorage in the loop that holds the copilot’s belt was not adequate and that the knot he tied was not properly executed (Fig. 5b).

Another accident occurred on June 26, 2015. The aircraft PR-EES, model EC 45, manufactured by Eurocopter Deutschland, while performing a rappel, in support of a police operation, had a crew member detached from the rope, coming crashing against the ground. The aircraft was not damaged. The crew member suffered serious injuries. The Final Report A – no. 092/CENIPA/2015 states that there was no evaluation sheet proving the adequacy of the performance of the Tactical Flight Officers, involved in the accident, regarding the performance of rappelling, based on the UAP’s training program. There was no formal designation of instructors of the procedure and the experience in the procedure had been acquired in the operation of AS-350 aircraft. There was no systematic process of adaptation to the EC45 model (CENIPA 2015).

Other accidents with similar circumstances occurred with the aircraft PP-EOW (07/16/2020), PR-HFA (07/18/2019), PP-EOY (02/22/2018), PR-HGH (09/11/2020), PR-HTA (11/06/2020).

In the PT-HZL and PR-EES accidents, CENIPA made the following safety recommendations:

- Implementation of a performance evaluation of the tactical flight officer, according to the training program;
- Compliance faithfully with the sequences of actions established in the *Manual of Operating Procedures*;
- Emphasis in the unit’s operational doctrine the individual equipment checks and anchorage in the aircraft before each takeoff;
- Schedule, periodically, of the recycling of its crew members in relation to knots and anchorages;
- Providing the fulfillment of service bulletin 25.00.65.000 that foresees the installation of rings on the floor for tying cables or ropes for the aircraft;
- Providing the safety equipment *monkey tail* PN 350 A84-0047 of IPC 25.63.10, indicated by the aircraft manufacturer, for use by the tactical flight officer when necessary.

DISCUSSION

Regulatory Aspects Related to Operation and Certification of Aeronautical Products

As established in Subpart F of RBAC 90 (ANAC 2019a), special public aviation operations must be performed with aircraft and equipment certified by ANAC in accordance with RBAC 21 and 27. In addition, paragraph (d), section 90.5 of RBAC 90 emphasizes that in the absence of an operational requirement expressed in that standard, UAPs must comply with related regulations, in this case, RBAC 91 (ANAC 2021a).

The general requirements for certification of aeronautical products and articles are prescribed in RBAC 21 (ANAC 2021b) and are complemented by specific airworthiness requirements described in RBAC 27 (ANAC 2013).

According to Sections § 27.2, 27.561, 27.562, 27.625, 27.1307, 27.1413 of RBAC 27 and TSO-C114, the manufacturer must demonstrate that the helicopter has an approved seat and shoulder belt (upper torso restraint) for each occupant that is equipped with a metal-to-metal latching device. In addition, the regulation requires that the helicopter’s safety belt must be able to withstand inertial forces multiplied by an adjustment factor of 1.33, including in emergency landing situations (ANAC 2013).

Covering all aspects related to certification, there are the operational requirements established in RBAC 91. This standard requires that a person must keep his seat belt buckled while at his workstation. This requirement is provided in paragraph (a)(2), Section 91.105. Section 91.107 also requires that every person aboard a Brazilian civil aircraft must occupy a seat in the aircraft with his seat belt properly fastened (ANAC 2021a).

Hence, the need for movement on board of the tactical flight officers, in its various tasks performed in public security aircraft requires, therefore, substitute devices that fulfill its functional role and ensure effective safety.

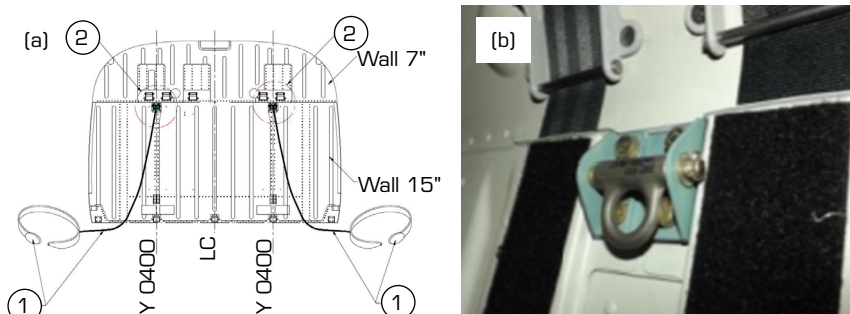
This replacement must occur with the use of equipment that meets the regulatory aspects related to the operation and certification of aeronautical products mentioned above.

Within the scope of this study, we analyzed the *spider*, *monkey tail* and *baudrier* tying devices, and the existence of certified equipment that meet the other requirements. This analysis focuses on the rotary-wing aircraft widely used by UAP, the AS350, keeping the old Eurocopter designation, now Airbus H125 (Piloto Policial 2009-2019), and since most accidents involving human harnesses, in Brazil, occur in this aircraft model.

A Supplemental Type Certificate (STC) is, in essence, a certificate issued when an applicant receives regulatory agency approval for a major modification/change to an aeronautical product from its original design.

Regarding the compliance with the requirements for the installation of the belt, the AS350 manufacturer has the STC 2012S09-13, which consists of the installation of sets (hardware/hook-up ring), fixed on the wall, behind the passenger seats and used for the attachment of the belt sets, and the referred installation is composed of a belt on the left and right side of the aircraft (Fig. 6a, b).

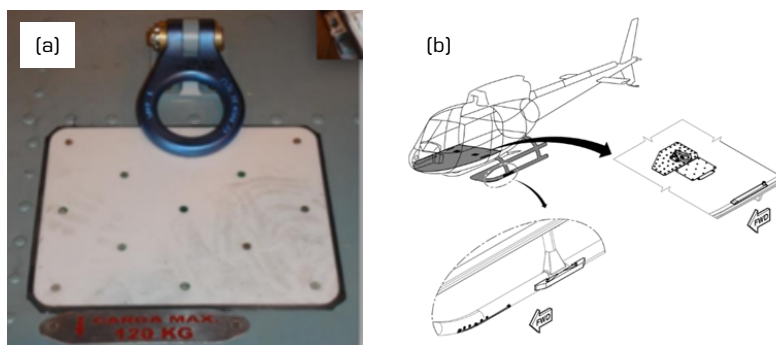
Similarly, Helibrás (2016) issued Service Bulletin 25.00.65.000, regarding the installation of rings on the floor for tying cables or ropes (rappel), and is applicable to aircraft equipped with two sliding doors, and each ring is limited to 120 kg.



Source: (a) Helibrás (2016, p. 1), (b) The authors.

Figure 6. (a) STC 2012S09-13 and (b) coupling ring.

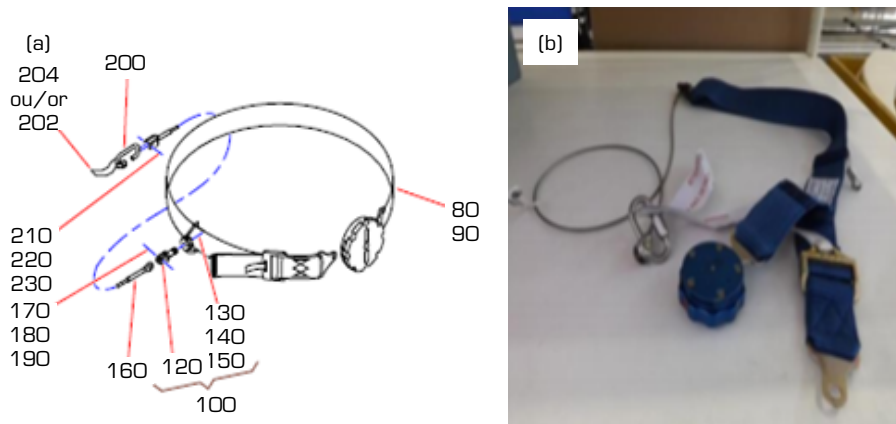
The installation of rappelling provisions involves hitching ring assemblies installed on the cabin floor, and protections for the floor, the step, and the landing gear. This solution eliminates the need for the *spider*, which is not a certified product and meets one of CENIPA's safety recommendations (Fig. 7).



Source: (a) The authors; (b) Helibrás (2016, p. 1).

Figure 7. Rappelling provisions and Service Bulletin 25.00.65.000.

Regarding the hoist belt safety equipment, the manufacturer provides a device that is certified according to IPC 25.63.10 PN 350A84-0047, recommended for the use of the crew (Fig. 8).



Source: Helibrás (2016, p. 2), The authors,

Figure 8. Monkey tail PN 350 A84-0047 sketch and monkey tail.

Finally, *baudrier* equipment is considered by the FAA to be a Personnel Carrying Device System, under TSO-C167 and available on the market by commercial dealers such as CMC Rescue, Inc. which produces the Air-Rescue Harness (CMC 2018), as well as Lifesaving Systems which produces the Triton Rescue Harness (Lifesaving 2021).

There are, accordingly, options for the *spider*, *monkey tail* and *baudrier*, which make up the human harnesses of Tactical Flight Officers, properly certified by the civil aviation authority and meeting current regulatory requirements.

Specific aspects for operation with HEC

For special public aviation operations, when there is a need for HEC transportation, RBAC 90 is the normative that deals with the requirements to which UAP's are subject. These operations include fast rope, McGuire, rappel, etc. As for transport operations with external cargo, RBAC 90, in item 90.389 (b) states that:

The ropes, cargo nets, straps, personal use equipment and other items used in the tying of external cargo:

(1) will not be subject to ANAC certification; however, they must follow minimum safety criteria established by UAP in the SOP (ANAC 2019a, p. 119).

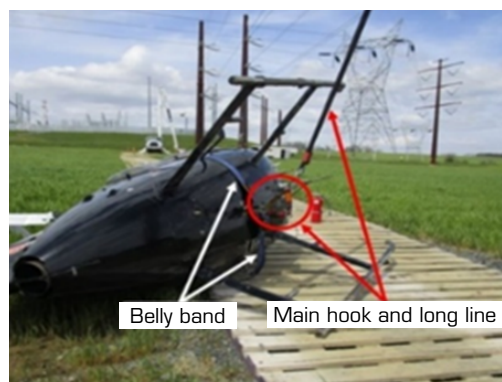
Therefore, certification is not required for accessory equipment used in the transportation of HEC, as FAA does, and unlike the UK CAA. However, it is essential to make operators aware of the operational risks of this activity. Inadvertent release of cargo, especially a human external load, is a safety issue, while the inability to release the load in an emergency is also a safety concern (Fig. 9).

The supplementary conditions for HEC operations, prescribed in part 90.379, of RBAC 90 (ANAC 2019a, p. 110), states:

(7) the risk of inadvertent release of the live load is mitigated within the operational safety risk matrix;

... (12) the person to be hoisted is properly secured to the safety system or safety belt before being released to the rope;

... (16) other procedures at the discretion of the UAP. (c) (2) comply with the SOPs defined by UAP.



Source: Hughes (2020).

Figure 9. McDonald Douglas MD369D helicopter, registration N9159F.

In this perspective, Art. 168 of the Brazilian Aeronautical Code states that the pilot may dispose of cargo when it is indispensable to flight safety:

Art. 168 During the period of time established in article 167, the captain exercises authority over people and things on board the aircraft and may III – throw away the cargo or part of it, when indispensable to flight safety. (our translation)

The use of belly band or other emergency anchorage is the way to mitigate the operational risks of inadvertent release, as long as it does not compromise the possibility of emergency release even through emergency operational procedures.

Although accessories are not required to be certified, it is cleared up that there is one company (Boost Human External Cargo Inc.) that has certified complete systems in compliance with the 27.865 requirement (Boost Human External Cargo Dual Hook System). Boost obtained an FAA STC (STC) for its HEC system for the AS350/355 series in March 2016, and for its Bell 407 HEC system in March 2017 (FIGURE 17). In short, the said device has hook redundancy (two) with independent jettisoning systems (STC SH15-39).



Source: Boost (2020).

Figure 10. Human external cargo.

Also, in the airworthiness requirements described in RBAC 27, the certification of the aircraft is subject to proof of compliance with various technical and regulatory criteria. Among these are the weight and center of gravity limits, in addition to an entire chapter that addresses the performance of the equipment, in which the characteristics of takeoff, landing, autorotation, controllability and maneuverability requirements and the height-velocity envelope are evaluated; likewise, the flight characteristics, endurance requirements, and numerous other aspects of design and construction. Specific airworthiness criteria for external loads are written in § 27.865 (ANAC 2013).

It is recognized that there are operational limitations resulting from the certification of the aircraft itself at the interface with the use of this aircraft with crew members moving inside the helicopter or when transporting HEC. Considering that the aeronautical authority does not establish specific requirements, leaving it to the discretion of the public air units to evaluate this type of operation, RBAC 133 (ANAC 2019b), in combination with the other standards already mentioned, can be used to provide a baseline for the procedures to be developed and respected by the UAPs regarding the operational envelope of the aircraft, maximum turn and pitch ratios, altitudes, maximum forward speeds, accelerations and interaction with the tail rotor, among other features, generating new operating procedures.

These aspects are well detailed in chapter 133.47, which states that a flight manual for the aircraft-external load combination must be developed and submitted to ANAC for approval, containing operational limitations, procedures (normal and emergency), and performance, among other information (ANAC 2019b). This is also in accordance with chapter 91.9 of RBAC 91 (ANAC 2021a) that deals with the requirements for the aircraft operation manual, that only allows the operation of a civil aircraft if the operational limitations specified in this manual and the markings and placards posted on it are met.

Legal Risks

In Public Administration, managers are subject to the principle of legality, i.e., one can only do what is in the law, according to the 1988 Constitution of the Federative Republic of Brazil.

It should be noted again that special public aviation operations are not immune from compliance with the complementary provisions expressed in correlated regulations. It is, therefore, unequivocally up to the managers of these units to comply with the laws, rules and other regulations inherent to these activities.

RBAC 90, in subpart E, lists the general requirements for personal protective equipment. These requirements permeate the policy of use, inspection, and disposal, in addition to procedures, training, and experience of the crew in order to reduce the probability and severity of accidents and to maintain the acceptable level of performance of operational safety (ANAC 2019a).

In the same normative, in subpart N, it is determined that the UAP must establish a policy for the use of human harnesses and other safety equipment, increasing even more the legal responsibility of the managers (ANAC 2019a). In these terms, it is also the pilot-in-command's responsibility to authorize the onboard movement, the transportation of human external load, and the disembarkation of the aeronautical operator (90.21).

It should be added that in the units, the managers must decide in relation to the tolerability of risks to operational safety in all aspects, such as training, recycling, on-board functions, manuals and other special operations.

In view of the above, it is observed that noncompliance with these regulatory provisions associated with the use of noncertified products may lead to risks of legal liability for managers and aircraft captains.

Regulatory Alternatives

RBAC 90 provides UAP with the regulatory limits for the performance of their activities. As in any regulation, when regulatory issues are identified that may embarrass the correct understanding and application of these rules, the regulation may be submitted to a regulatory impact analysis for updating, adjustment, and improvement under the terms of Decree 10,411, dated June 30, 2020.

Considering that the human harnesses are complex, aim to meet specific operational criteria of the UAPs, and that there is evidence that such equipment has been a contributing factor in some accidents and fatalities in public air units, it is clear that there is a regulatory problem in RBAC 90 to be evaluated by ANAC.

Therefore, and based on international references, it is noted the presence of a regulatory alternative to be assessed by ANAC within the regulatory impact analysis.

This regulatory alternative deals with the possibility of approval of a safety equivalent level to requirements 27.2 (a), 27.625 (d), 27.1307 (b), and 27.1413 of RBAC 27 by the civil aviation authority, in accordance with Subpart D of RBAC 11 (ANAC 2020). That is, ANAC along with the regulated industry would admit the use of consensus standards approved by recognized entities, such as the American Society for Testing Materials (ASTM), the National Fire Protection Association (NFPA), and the Society of Automotive Engineers (SAE).

Such regulatory practice is similar and already adopted by the US civil authority for helicopter operations with external loads in the context of FAR Part 133 and Safety Alert for Operators 18013 (FAA 2018b). Since few human harnesses are currently properly certified, and given the possibility of operational and safety losses to air operators, the authority expects manufacturers to design, develop and certify human harnesses. In addition, SAFO itself recommends, in the context of public aircraft operators, similar to Brazilian UAP context, that when using such components, risk assessment should be conducted and appropriate mitigation measures applied when conducting operations with HEC.

This regulatory option is legally supported by art. 67 §1, combined with art. 66 of Law 7,565, dated December 19, 1986, which allows the Brazilian civil aviation authority to receive exceptional approval for components that have not yet been certified by ANAC, as long as the level of operational safety is not compromised:

Art. 66 - The aeronautical authority is responsible for promoting flight safety, and shall establish minimum safety standards:

Art. 67. ...

§ The aeronautical authority may, exceptionally, permit the use of components not yet approved, provided flight safety is not compromised.

As a consequence, the UAPs would have greater operational flexibility and legal security to fulfill their missions.

The forum “Oversight of Public Aircraft Operations: Ensuring Safety for Critical Missions,” held in 2011, aimed to emphasize the importance of effective supervision in public aircraft operations (US National Transportation Safety Board 2011).

Two of the most important goals of this forum is to raise awareness about the importance of effective supervision and also to facilitate the sharing of best practices and lessons learned in the conduct of public aircraft operations. These objectives can be implemented with integration between the public air units themselves as well as between the units and the civil aviation authority.

The management of the acceptable level of risk involves risk perception, identification and subsequent elimination/mitigation. It is suggested that public air units be widely informed of the number of accidents involving these devices and of the other restrictions and alternatives clarified in this work.

Public air units should implement new risk controls, as well as eliminate or modify existing risk controls to which Tactical Flight Officers are subjected, in order to ensure operational safety.

A proactive management approach seeks to preventively identify operational safety risks before an event occurs. Reactive management assesses risks in response to an occurrence. Even with the accidents that have occurred in the last ten years, there may be tolerance of exposure to expendable hazards. As mentioned earlier, it is up to managers to decide on the tolerability of operational safety risks in various aspects.

ANAC Resolution 512 (ANAC 2019c), which approved RBAC 90, established the deadline of April 12, 2021 for the implementation of all procedures and policies defined in the SOP by the UAPs. It has become urgent that the units prepare and approve these reference documents, a legal obligation of the units’ managers. These documents are essential to describe and standardize the Tactical Flight Officers’ attitude and their interaction with the other crew members, with the equipment and with the air unit itself, where the human factor is one of the safety links.

CONCLUSION

After identifying the regulations for the use of human harnesses and the possible regulatory obstructions, the legal implications to which public air units are subject to are detected.

The regulations associated to RBAC 90, of compulsory compliance by public air units, such as RBAC 21, 27 and 91, require that the human harnesses used by the Tactical Flight Officers meet the standardized criteria and requirements.

In view of these norms, it is clear that the UAPs use equipment (*baudrier*, *monkey tail* and *spider*) that do not have aeronautical certification approved by the civil aviation authority and, therefore, have not demonstrated compliance with airworthiness requirements for the safety of the aircraft crew and other occupants.

It is evident that the UAPs operate helicopters in apparent violation of the product certification requirements defined by ANAC and that may lead to compromising operational safety.

In the analysis of aeronautical accidents and incidents that occurred in the operations of public air units, in which the use of tying equipment was found as a contributing factor, we can identify the national scope and a continuous chronology: 2010, 2015, 2018, 2019 and 2020. There is, therefore, a need for the reduction of these events.

Given all that was found, it is understood that public air units have regulatory weaknesses and operational requirements that result in accidents with fatalities, resulting in an unacceptable level of risk to be corrected/mitigated by the Brazilian authorities involved in public air operations.

As recommendations, public air units must implement and maintain the Safety Management System according to subpart K of RBAC 90. The adoption and effectiveness of the Safety Management System is a key element to reduce the exposure to risk factors inherent to the public aviation safety activity.

In addition, in order to reduce accidents and incidents in the UAPs, the tools to be used include the management of the acceptable level of risk, analysis of the human factors involved, updating of the operational techniques and implementation of the flight safety culture.

In these operational documents the policy for the use of human harnesses and other safety equipment must be established, which also passes through the implementation of evaluation criteria, both for the equipment and the Tactical Flight Officers' performance, according to the organization's training programs and procedures.

In the same way, for the promotion of the organizational safety culture, one of the requirements is training, qualification and continuous recycling. The training and qualification processes of Tactical Flight Officers require a thorough initial training and continued qualification. Without the effective use of the units' SOPs, not only the organizational safety culture is undermined, but also there is no legal security for managers and captains.

AUTHORS' CONTRIBUTIONS

Conceptualization: Vilela ARA; **Methodology:** Vilela ARA; **Validation:** Vilela ARA; Guerrante MG; **Formal analysis:** Vilela ARA; **Investigation:** Vilela ARA; **Resources:** Vilela ARA; **Data Curation:** Vilela ARA; **Writing - Original Draft:** Vilela ARA; **Writing - Review & Editing:** Vilela ARA; Guerrante MG; **Visualization:** Vilela ARA; **Supervision:** Vilela ARA; Guerrante MG; de Andrade D; **Project administration:** Vilela ARA; Guerrante MG.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable.

FUNDING

Not applicable.

ACKNOWLEDGEMENTS

Not applicable.

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