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Risk Factors Associated With The Violation Of Regulatory Requirements In The Maintenance Of Aircraft Components

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Abstract

An Aircraft Component Maintenance Organization must secure operating authorization through approval from relevant Regulatory Agencies. These Agencies issue a certificate of approval, granting Organizations the right to operate engines and aircraft products for customers in the countries under their jurisdiction. The certificate is granted by Regulatory Authorities following inspections of Maintenance Organizations, ensuring compliance with applicable regulations. These regulations are crafted to guarantee that services adhere to necessary parameters and requirements, ensuring the ultimate quality of the product. Compliance holds heightened significance in aviation, given the potential direct impact on end customers and the risk of severe air accidents resulting from non-compliance. This study focuses on identifying risk factors associated with regulatory non-compliance. The Objective is to propose improvements and mitigate risks during the maintenance process. The study analyzes information on compliance with aircraft components maintenance regulations by companies. As a methodological approach, a case study was conducted using interviews with subject matter specialists to contribute to mapping risk factors associated with regulatory violations. The Analytic Hierarchy Process (AHP) methodology is employed to determine the impact of these risks on companies. Subsequently, actionable measures are recommended to minimize the impact of risks. The study underscores the significance of each regulatory requirement, emphasizing that none can be overlooked, as they all carry similar importance. Despite focusing on the Maintenance of Aircraft Components, the study highlights the universal importance of regulations in any business sphere, demonstrating adaptability to various industries. This research can be a foundational framework for future studies delving into a company's risks and may apply to diverse business sectors. This study is essential for professionals dealing with compliance with regulations in organizations and sets the stage for future academic research, inspiring scholars to delve deeper into complying with regulations.

Keywords: aeronautical, regulations, risk, management, analytic hierarchy process

1. Introduction

An aircraft product maintenance organization must obtain authorization from relevant regulatory agencies. Key agencies include ANAC (Brazil) and FAA. (United States), which issue approval certificates, granting organizations the right to operate on engines and aircraft products within their countries. These certificates are awarded after regulatory authorities conduct inspections, ensuring compliance with applicable regulations. For Repair Stations, ANAC follows RBAC 145, while the FAA adheres to CFR PART 145. These regulations, organized into subparts, delineate compliance requirements across various factors, such as facilities, resources, equipment, personnel, etc. Strict adherence guarantees an organization's compliance with processes, airworthiness, and Safety in the aircraft field. This study identifies and assesses risk factors associated with non-compliance, considering potential consequences for the company and aviation. Regulations exist to ensure services adhere to necessary parameters, which are crucial for the final product's quality. In aviation, compliance is paramount, given that its lack can cause severe accidents and impact end customers. Understanding and mapping these regulations can aid in recognizing associated risks. This study proposes preventive actions to mitigate risk factors, utilizing an AHP to identify and classify non-compliance risks. Maintaining aircraft engines governed by regulatory agencies is vital for ensuring correct functioning, quality, and Safety. This study lists risk factors related to non-compliance, drawing on the knowledge of experts to propose improvements and minimize risks during the maintenance process.

Due to the complexity of maintenance processes and many regulatory requirements, constant monitoring is essential to address problems preemptively. Non-compliance can result in rework, increased costs, delayed deliveries, withdrawal of maintenance service authorization, and, in extreme cases, plane crashes. The study's significance lies in its ability to map out risk factors, enabling organizations to strategize and behave to avoid failures, enhance productivity, reduce rework, and improve the quality and Safety of products.

Two key research questions guide the study:

Research Question 1: What are the critical factors related to non-compliance with regulations?

Research Question 2: What actions should be taken to minimize the impact of these risks?

The study is structured into five sections: an introduction, a literature review, a methodology, a case study, and a conclusion. Each section contributes to understanding and addressing the challenges posed by non-compliance with aircraft regulations.

2. Literature Review

This section presents up-to-date studies on the subject, intending to provide a basis for a better understanding of aircraft regulations applied to Aircraft Engine Maintenance Organizations and risk management.

2.1. Aircraft Regulations applied to Maintenance Organizations.

We are presently residing in the era of globalization, marked by a notable surge in global air traffic. This increase has heightened the likelihood of incidents and air accidents worldwide. There is a pressing need to diminish these accidents, underscoring the imperative to enhance operational Safety in specific domains (Rodrigues, 2014). The Aeronautics Command Manual (MCA.) defines contributing factors as conditions (acts, facts, or combinations thereof) that, in conjunction with others, either sequentially or as consequences, lead to the occurrence of aircraft accidents, incidents, or ground occurrences or contribute to the exacerbation of their consequences (Messias, 2017). Aircraft maintenance has been identified as a contributing factor in investigating numerous air accidents scrutinized by CENIPA. Between 2006 and 2015, there were 1294 aircraft accidents and 526 serious incidents. Of the 766 final reports published on aviation accidents during this period, aircraft maintenance as a contributing factor is implicated in 167 incidents, constituting 21.8% of the total. Likewise, out of 224 final reports on serious aircraft incidents, aircraft maintenance contributes to 80 incidents, making up 35.7% of the total reported (Messias, 2017). Regulation is inherent in every civil aircraft activity, reflecting the historical understanding that the commercial viability of aviation depends on prioritizing flight safety. This ensures that the aviation system poses minimal risks to the integrity of individuals and goods transported (Teixeira, 2007). The regulatory landscape for aeronautics evolved post-First World War when the potential of aviation, previously viewed as experimental or military, was realized. This era witnessed the birth of numerous aircraft manufacturers, a surge in air traffic, and a proportional increase in aircraft accidents (Heppenheimer, 2000). Over time, it became evident that high rates of aircraft accidents were linked to a systematic lack of control over factors such as aircraft design, manufacture, materials and processes, aircraft operation, maintenance, crew training, and airport and air traffic control infrastructure (Teixeira, 2007). In 1944, the Chicago Convention gave rise to the International Civil Aviation Organization (ICAO), a UN agency responsible for establishing international standards and practices. It recommended procedures encompassing the global civil aviation system's technical, economic, and legal aspects. The ICAO guides the international regulation of aircraft activity in all aspects (Teixeira, 2007). At the national level, each country's civil aviation authority (ANAC, FAA., EASA, TCCA, CAAC, among others) regulates aircraft activities. The challenge for these regulatory agencies is to promote flight safety, user safety, the efficiency of the aircraft system, and the sustained growth of this economically vital activity through policies and rules governing all facets of the aircraft system (Teixeira, 2007). While each country determines civil aviation requirements through its civil aviation authorities, an international treaty facilitated by ICAO defines common standards and recommended practices for operational cooperation, ensuring the safe operation of a global aviation network. Each country must become a signatory to this treaty (Soares, 2017). In Brazil, the National Civil Aviation Agency (ANAC), established in 2005, regulates and oversees civil aviation, succeeding the Civil Aviation Department (DAC), which was subordinate to the Brazilian Air Force. ANAC, a federal authority under a special regime, is linked to the Ministry of Transport, Ports, and Civil Aviation. Its activities encompass certification, inspection, standardization, and institutional representation (ANAC, 2017). The Brazilian Aircraft Homologation Regulations (RBHA) and the Brazilian Civil Aviation Regulations (RBAC) stipulate the minimum safety standards for operators in the civil aviation system (Santos, 2017). The Federal Aviation Administration (FAA.), established in 1958, is the regulatory body for aeronautics in the United States, boasting the largest aircraft fleet globally. Its expertise positions it as a benchmark in civil aviation, having established the world's safest, most reliable, and most productive aviation system. Several countries, including Brazil, draw inspiration from the FAA. requirements when formulating regulations (Santos, 2017). Aviation safety is conceptualized in various ways, such as risk-free operations, zero serious incidents or accidents, and preventing errors and occurrences. However, as stated in the ICAO Safety Management Manual - 9859, these objectives are deemed unattainable in dynamic operational contexts. According to the Centre for Investigation and Prevention of Aircraft Accidents (CENIPA), Flight Safety referred to as Safety, pertains to operational Safety specifically applied to air activities to prevent aircraft occurrences (Leal, 2021). Aircraft regulation constitutes a framework of laws, rules, and regulations guiding the operation of the aviation industry and aircraft activities. This regulatory framework ensures the Safety of air operations, passenger protection, and environmental preservation. The studies presented above underscore the critical role of aviation regulation in civil aviation. Gerede, E. (2015) investigated the challenges to the successful implementation of SMS in aircraft maintenance organizations, the degree of priority of these challenges, the major problems affecting the performance of SMS, the factors causing the problems, and the ensuing results. Shanmugam and Robert (2015) study provided the criteria and scientific approach for assessing the maintenance organization; it presents a methodology of applying Analytical Hierarchy Process to prioritize the key functions and to rank the maintenance organizations under study. The study has established that maintenance service quality in airline is directly correlated to its fleet size. Clare, J., & Kourousis, K. I. (2021) identified gaps in the European implementing rules that could be addressed in the future to support a more effective approach to the delivery of lessons in the aircraft maintenance and continuing airworthiness management sector.

2.2. Risk Management and Violation

A risk is an event that, if it occurs, could have either a positive or negative impact on the success and objectives of projects. Stoneburner et al. (2002) define risk management as a process aimed at identifying, evaluating, and treating risks, reducing them to a level acceptable to organizations. The Australian and New Zealand technical standard for risk management, a precursor to the ISO 31000 international standard, defines risk as "the chance of something happening that has an impact on objectives." Likewise, it characterizes risk management as "the culture, processes, and structures aimed at realizing potential opportunities for managing adverse effects" (Standards Australia, 2004). Risk management enables the establishment of priorities and the guidance of decision-making based on scientifically and statistically grounded estimates of the probability of occurrence, the nature, and the magnitude of future impacts on the organization's objectives (Hollós & Pedersoli, 2009). Effective risk management presupposes implementing a continuous process within the organization involving the support and participation of all its segments. According to the Australian and New Zealand technical standards, this process comprises five sequential steps: (1) establishing the context, (2) identifying risks, (3) analyzing risks, (4) assessing risks, and (5) treating risks. The continuous steps crucial for successful risk management involve consultation, communication with all stakeholders, and monitoring and reviewing the process (Hollós & Pedersoli, 2009). Risk, intrinsic to any personal, professional, or organizational activity, can lead to losses and opportunities. Symbolically, risk can be represented as the product of the probability of a given event occurring multiplied by the magnitude of the consequences. In agreement, though not precisely, the term describes the probability of an unexpected event. At this point, it is a factor that can be exploited to obtain decision-making tools (Eneterio, 2020). Risk management is structured and implemented by national and international entities related to regulation and standardization through guides, manuals, and standards such as COSO, ABNT, and PMBOK. Generally, risks can be categorized according to their origin, nature, impact, probability of occurrence, or duration. Typification is relevant for prioritizing and helping build cause-and-effect models and designing risk management systems (Eneterio, 2020). According to Carvalho (2012), non-conformity refers to a failure to meet expected requirements, such as a defective product, late delivery, a service provided incorrectly, or failure to comply with customer demands. Non-compliance in an organization is linked to processes that, in some way, provide an unsatisfactory result (Campos, 2013). To prevent non-conformities, companies have adopted quality management systems, as Santos et al. (2014) suggested, which standardize an organization's methods and practices, avoiding products that do not meet customer expectations. Compliance necessitates a sense of self-discipline by observing and following standards, rules, and procedures and meeting written or informal specifications (Rossato et al., 2016). Whenever there is a non-conformity in an organization, corrective actions are necessary to eliminate the causes and prevent recurrence (Fedozzi, 2014). Authors emphasize the need for a systematic analysis of the interactions between identified non-conformity factors and the production process (Farooq et al., 2016). Non-conformity is a deficiency in a characteristic, product specification, process parameter, record, or procedure that renders the quality of a product unacceptable, undetermined, or outside established requirements. It is a component, manufacturing material, or finished product that is out of specification before or after distribution. This implies that developing a product or service involves some manufacturing process (Marrafa, 2015). Studies demonstrate that risk management and non-conformities are interconnected, as many non-conformities can be related to previously identified risks. For instance, if a company identifies the risk of failure in a process, a subsequent non-conformity may result from this failure. The company must establish a quality and safety culture involving all employees and promote the continuous improvement of processes and procedures to ensure the effectiveness of risk and non-conformity management. Pereira et al. (2015) emphasized the crucial role of probabilistic risk analysis in the manufacturing process of jet engines to prevent failures. The authors introduced a probabilistic risk analysis model to assess the safety of this manufacturing process. In a related context, Pereira and Fayer (2020) proposed a method for strategic decision-making, focusing on the identification and prioritization of potential risks that could disrupt production in steel production processes during a water crisis scenario. Furthermore, Pereira et al. (2017) highlighted in their study that the current reliance of industries on quality management for economic development underscores the necessity for research on the sustainability of organizations. Current studies on quality and organizational sustainability often overlook the inclusion of quality management risk factors that could impact organizational sustainability. Addressing this gap, Fayer et al. (2018) developed a model and conducted risk analysis using Analytic Hierarchy Process (AHP) and Bayesian Belief Network (BBN) tools to evaluate risks arising from a water crisis scenario in the steel industry. The goal was to ensure the availability of water resources necessary for the safe operation of the industry. Moreover, Pereira et al. (2014) utilized design thinking as a suitable technique for analyzing human factors risks, specifically in preparation for quantitative risk analysis. The authors asserted that the advantages of this technique are apparent and have practical implications for specialists involved in identifying human factor risk factors in quantitative risk analysis. In conclusion, the studies collectively emphasize the fundamental importance of pursuing quality, whether in the aerospace industry, information systems, or organizational processes. The adoption of standards, systematic approaches, and recognition of information as a strategic asset are deemed essential for achieving and sustaining high-quality outcomes. Well-documented processes, continuous monitoring, and a commitment to improvement all contribute to organizational effectiveness and adaptability.

2.3. Analytical Hierarchy Process

The multi-criteria decision support methodology is a valuable tool in decision-making, particularly in situations with a wealth of information. This becomes crucial in guiding the decision-making process effectively. By employing methods that comprehend and map the decision perspective, applicable concepts generate outcomes aligned with the established criteria. Consequently, these methods facilitate a comprehensive overview of the entire scenario (Lopes & Pantaleão, 2019). Multi-criteria programming, utilizing the AHP, presents a structured approach for decision-making in complex environments where numerous variables or criteria influence the prioritization and selection of alternatives or projects (Vargas, 2010). The AHP, pioneered by Thomas Lorie Saaty in 1971, stands out as a straightforward and valid multi-criteria decision support methodology. It accommodates both qualitative and quantitative data without distinction regarding tangibility. Components are hierarchically dissected, followed by pairwise comparisons (binary combinations). These comparisons facilitate prioritization, ultimately leading to optimal decision-making (Jordão & Pereira, 2006). The AHP method is the most widely recognized and utilized multi-criteria approach for decision support, particularly in resolving negotiated conflicts within problems featuring multiple criteria (Marins et al., 2009). Its application extends to diverse, complex scenarios where collaborative decision-making involves human perceptions, judgments, and consequences with long-term implications (Bhushan, 2004). The method is rooted in Newtonian and Cartesian thinking, aiming to address complexity by breaking down and categorizing the problem into factors that can be further decomposed into transparent and scalable levels. The subsequent synthesis involves establishing relationships among these factors (Marins et al., 2009). The AHP application commences with breaking down the problem into a hierarchical structure for independent analysis and criteria comparison. Decision-makers systematically assess alternatives by pairwise comparisons within each criterion, employing concrete data or human judgments as underlying information (Saaty, 2008). The weights assigned to each factor enable the evaluation of elements within the defined hierarchy, distinguishing AHP from other comparative techniques (Vargas, 2010). According to Saaty, selecting decision-making factors is paramount, significantly influencing the decision outcome (Amaral et al., 2021). Both criteria and alternatives must be structured hierarchically, with the first level addressing the problem's purpose, the second level encompassing criteria, and the third level incorporating alternatives (Marins et al., 2009). Bornia and Wernke (2001) asserted that hierarchical ordering enables decision-makers to visualize the system comprehensively, understanding interactions and impacts. This global perspective allows for a standardized assessment of criteria elements (Marins et al., 2009). According to Vargas (2010), AHP transforms comparisons, often empirical, into numerical values processed and compared. The weight of each factor allows the estimation of each of the elements within the defined hierarchy. This ability to convert empirical data into mathematical models is the main differentiator of AHP concerning other comparative techniques. Once all comparisons have been made, and the relative weights between the criteria to be evaluated have been established, the probability of each of the alternatives is calculated. This probability determines the alternative's probability of meeting the established goal. The higher the probability, the more that alternative contributes to the goal. The first step of the AHP is to build a pairwise comparison matrix. Each element aij (i, j = 1, 2, ..., n) represents the relative importance of elements i and j. A higher value denotes a stronger preference of element i over element j (Pereira; Almeida, 2021).

3. Methodology

The study adopted the approach of building theory from Case Study Research proposed by Eisenhardt (1898), Baxter and Jack (2010), Yin, R. (2014), and Hancock et al. (2021). It combined data from standards, civil aviation regulations, archives, and interviews. The steps taken to capture the data needed to analyze the risk factors are 1 - Analysis of the theoretical framework and up-to-date literature; 2 - Preparation of a table containing the subparts of the aviation regulations applicable to a maintenance organization; 3 - Interviews with experienced experts to generate potential risk factors associated with non-compliance with these requirements; 4 - Use of the AHP to categorize the risks presented and based on the risk factors identified, propose desirable actions to mitigate the risks.

3.1. Population and Sample

The study analyzed non-compliance risks with applicable aircraft components maintenance regulations. The number of stakeholders participating in the study is listed in Table 1. These stakeholders were selected based on their expertise in a specific domain. The sample size is adequate and meaningful since all the studied areas are covered and the participants are high knowledgeable and experienced in regulatory compliance, having interfaced with different regulatory authorities from all over the world for many years.

Table 1. Stakeholders participating in the study.

Area	Function	Number of participants	Experience in years
Quality	Senior Engineer	1	37
Quality	Quality Manager	1	12
Quality	Quality Specialist	2	3

3.2. Instruments and Tools

The study adopted a theory-building approach based on case study research. It combined data from archives, interviews, and observations. A table was drawn up to show the risk factors related to non-compliance with each subpart of the applicable regulation, as well as suggestions for actions that could prevent these requirements from being met.

3.3. Data collection

Data was collected by analyzing aviation regulations, reviewing state-of-the-art literature, and interviewing stakeholders from aircraft component maintenance companies to understand the associated risk factors.

3.4. Data analysis

The risk factors were mapped with the help of experts in aviation regulations, and an in-depth literature review was carried out on the impact of violating regulatory requirements. The experts listed the 10 (ten) most critical risks from their point of view. With these points chosen, AHP was used to determine which risks had the most significant impact. Once the risks with the most significant impact had been determined, appropriate actions were recommended to minimize these impacts.

4. Results

Table 2 presents the aircraft regulations (Part 145) of the two main Civil Aviation Authorities broken down into their subtopics, the risk factors associated with violating these requirements, and the proposed action to be taken to minimize these impacts for the company. Tables 3 and 4 show the application of the AHP to determine which risk factors impact.

4.1. Aviation Regulations and Risk Factors

Table 2 relates the subparts of ANAC and FAA regulation 145 and the responses provided during interviews with experienced professionals in the field of aviation regulation. This table shows the risk factors for the company in the event of a violation of the subparts described. The question asked during the interview was: 'If the company does not fulfill requirement x, what risk factor would this violation bring to the company?'

Table 2. Subparts of ANAC and FAA regulation 145.

ANAC	FAA	Risk Factors
145.103 - Requirements for facilities and resources	145.103 - Housing and facilities requirements	Withdrawal of certification because it is a basic requirement, without which it will not be possible to guarantee fulfillment of the requirements.
145.105 - Change of location, facilities or resources	145.105 - Change of location, housing, or facilities	Quality manuals, certificates, and operating specifications will be out of date. If this is a significant change, the certificate may be invalidated.
145.109 - Requirements for equipment, tools and technical data	145.109 - Equipment, materials, and data requirements	The company will be unable to start maintenance operations on aero engines.
145.151 - Personnel requirements	145.151 - Personnel requirements	The company would have unqualified employees to carry out the operations, reducing person-hours (HH), and impacting productivity and product delivery (TAT).
145.153 - Supervisory personnel requirements	145.153 - Supervisory personnel requirements	Supervisors' lack of qualifications could impact their ability to provide technical support to their employees.
145.155 - Inspection personnel requirements	145.155 - Inspection personnel requirements	Quality Escape can occur, as inspectors are the company's last quality barrier and can deliver non-conforming products to the customer.
145.157 - Personnel authorised to approve an article for return to service	145.157 - Personnel authorized to approve an article for return to service	The return to service inspection is mainly regulatory, so a failure in this process characterizes a failure to comply with the regulatory requirement, and the Aircraft Authorities could sanction the company.
145.161 - Records of administration, supervision and inspection personnel.	145.161 - Records of management, supervisory and inspection personnel	Personnel whom the Aviation Authorities do not authorize may be carrying out critical functions and operations without the appropriate qualifications, in addition to the lack of traceability of their professional experience, generating a lack of transparency vis-à-vis the Authorities.
145.163 - Training requirements	145.163 - Training requirements	Unqualified personnel carrying out aircraft maintenance operations could invalidate the certification, as this is a critical and essential process.
145.165 - Training in dangerous articles.	145.165 - Hazardous materials training	Lack of training in dangerous goods could affect the Safety of air cargo leaving the company, and the lack of instruction could cause problems handling this cargo internally, causing damage to the product or affecting employee safety.
145.203 - Work performed at another location	145.203 - Work performed at another location	The product would be delivered without the required quality, as it could not guarantee that the requirements of approved technical literature and regulations were being met.
145.205 - Performing maintenance	145.205 – Maintenance	The lack of a maintenance program for facilities and equipment would cause damage to the product, people, and the environment.
145.207 - Maintenance organisation manual	145.207 - Repair station manual	Violating this requirement would impact the absence of certification, as it would not be possible to demonstrate to the Aircraft Authorities how we fulfill the Part 145 requirements they determine.
145.211 - Quality control system	145.211 - Quality Control System	Violating this requirement would impact the absence of certification, as it would not be possible to demonstrate to the Aircraft Authorities how we fulfill the requirements of Part 43 determined by them.
145.213 - Maintenance inspection	145.213 - Inspection of maintenance	Failure to fulfill this requirement would impact product conformity and could lead to Quality Escape.
145.214-I - Operational Safety Management System – SGSO		Failure to manage operational risks can impact mitigating them or at least keeping them within an acceptable level for the company.

145.215 - Capacity list	145.215 - Capability List	Carrying out services not approved by the Aircraft Authorities could lead to the suspension of certification.
145.217 - Subcontracted maintenance	145.217 - Contract maintenance	Generation of non-conforming products, as the supervision of these companies, would not guarantee that they complied with regulatory requirements.
145.219 - Record keeping	145.219 – Recordkeeping	Lack of traceability regarding records of aircraft maintenance activities.
145.221 - In-service trouble reports	145.221 - Service difficulty reports	Lack of early reporting by the Aviation Authority. These reports help Maintenance Organisations act preventively.
145.221-I - Periodic reports		Lack of transparency on the part of the company and the Aviation Authority.
145.223 - ANAC inspections	145.223 - FAA. Inspections	Revocation of current certification. Inability to apply for the new certificate.

Based on the requirements from Table 2, the ten most critical risk factors raised by the professionals interviewed were selected. Based on these ten risk factors, the table below (Table 3) was created to prioritize these risks with AHP. Using the Saaty Numerical Scale, a numerical scale was assigned to each of the ten selected risk factors. The matrix was normalized after classifying each risk factor, as shown in Table 4.

Table 3. Risk Factors comparison matrix.

	145.103	145.105	145.109	145.157	145.161	145.163	145.207	145.211	145.215	145.223
145.103	1	3	5	5	7	3	1	1	1	1/5
145.105	1/3	1	3	1/5	5	1/3	1/5	1/5	1/3	1/7
145.109	1/5	1/3	1	1/7	1/4	1/7	1/7	1/7	1/5	1/7
145.157	1/5	5	7	1	5	3	1/7	1/7	3	1/7
145.161	1/7	1/5	5	1/5	1	1/5	1/7	1/7	1/5	1/7
145.163	1/3	3	7	1/3	5	1	1/7	1/7	1/3	1/7
145.207	1	5	7	7	7	7	1	1	5	1/7
145.211	1	5	7	7	7	7	1	1	5	1/5
145.215	1	3	5	1/3	5	3	1/5	1/5	1	1/7
145.223	5	7	7	7	7	7	7	5	7	1
Soma	10.210	32.533	54.000	28.210	49.250	31.676	10.971	8.971	23.067	2.400

Table 4. Normalized Matrix.

	145.103	145.105	145.109	145.157	145.161	145.163	145.207	145.211	145.215	145.223	W
145.103	0.0979	0.0922	0.0926	0.1772	0.1421	0.0947	0.0911	0.1115	0.0434	0.0833	0.1026
145.105	0.0326	0.0307	0.0556	0.0071	0.1015	0.0105	0.0182	0.0223	0.0145	0.0595	0.0353
145.109	0.0196	0.0102	0.0185	0.0051	0.0051	0.0045	0.0130	0.0159	0.0087	0.0595	0.0160
145.157	0.0196	0.1537	0.1296	0.0354	0.1015	0.0947	0.0130	0.0159	0.1301	0.0595	0.0753
145.161	0.0140	0.0061	0.0926	0.0071	0.0203	0.0063	0.0130	0.0159	0.0087	0.0595	0.0244
145.163	0.0326	0.0922	0.1296	0.0118	0.1015	0.0316	0.0130	0.0159	0.0145	0.0595	0.0502
145.207	0.0979	0.1537	0.1296	0.2481	0.1421	0.2210	0.0911	0.1115	0.2168	0.0595	0.1471
145.211	0.0979	0.1537	0.1296	0.2481	0.1421	0.2210	0.0911	0.1115	0.2168	0.0833	0.1495
145.215	0.0979	0.0922	0.0926	0.0118	0.1015	0.0947	0.0182	0.0223	0.0434	0.0595	0.0634
145.223	0.4897	0.2152	0.1296	0.2481	0.1421	0.2210	0.6380	0.5573	0.3035	0.4167	0.3361

After normalizing the table, the average of each row is calculated, and the W index is obtained. This index will be used to determine which risk factors should be treated as a priority, as they will have the most significant impact on the company. Table 5 shows the risk factors prioritized using the AHP, with the factors that should be prioritized being those located at the top of the table.

Table 5. Risks Prioritization.

W	Part 145
0.3361	145.223
0.1495	145.211
0.1471	145.207
0.1026	145.103
0.0753	145.157
0.0634	145.215
0.0502	145.163
0.0353	145.105
0.0244	145.161
0.0160	145.109

4.2. Response Actions to Risks

After prioritizing the risks, the next step to be taken to guarantee the quality and Safety of the aircraft engine maintenance organization is to outline response actions to the risks presented above. Table 6 shows the response actions for each risk presented, respecting the classification order found in Table 5.

Table 6. Risks Responses.

Part 145	Risk	Response to risks
145.223	Revocation of the current certification. The impossibility of applying for the new certificate for some time is determined in each applicable legislation.	Allow the Aircraft Authorities to conduct periodic inspections according to demand and need, providing all the support and logistics.
145.211	Violation of this requirement would result in the absence of a certification, as it would not be possible to demonstrate to the Aircraft Authorities how we comply with the Part 43 requirements they determine.	Create and implement a quality control system and submit it to the Authority for approval. Keep the quality control manual current, ensuring compliance with the requirements.
145.207	Violating this requirement would impact the absence of certification, as it would not be possible to demonstrate to the Aircraft Authorities how we fulfill the requirements of Part 145.	Draw up, follow, and keep up to date a maintenance organization manual approved by the Aviation Authority.
145.103	Withdrawal of certification because it is an essential requirement, without which it will not be possible to guarantee compliance with the requirements.	Provide adequate facilities and resources to carry out the aero engine maintenance service.
145.157	Revocation of the current certification and the impossibility of applying for the new certificate for some time are determined in each of the applicable legislations.	Adequately qualify, in compliance with the requirements determined by the Aviation Authority, technical personnel authorized to approve an article for service return.
145.215	Violation of this requirement would result in the absence of a certification, as it would not be possible to demonstrate to the Aircraft Authorities how we comply with the Part 43 requirements they determine.	Create and keep up to date a Capability List containing information on the type of service and identification of the article that will be worked on in the maintenance organization.
145.163	Violating this requirement would impact the absence of certification, as it would not be possible to demonstrate to the Aircraft Authorities how we fulfill the requirements of Part 145.	Draw up and maintain a personnel training program consisting of initial and recurrent training.
145.105	Withdrawal of certification because it is a basic requirement, without which it will not be possible to guarantee compliance with the requirements.	Notify and submit to the Aviation Authority for approval any modification of location and/or change in facilities previously approved by it.
145.161	Revocation of the current certification. The impossibility of applying for the new certificate for some time is determined in each applicable legislation.	Create and keep available for the Aviation Authority a list of management, supervisory, and inspection personnel authorized to approve service returns and a work history summary.

145.109	Violation of this requirement would result in the absence of a certification, as it would not be possible to demonstrate to the Aircraft Authorities how we comply with the Part 43 requirements they determine.	Ensure the maintenance organization has the necessary equipment, tools, and materials. It must also ensure these resources are well-stocked, calibrated, and properly maintained.

By analyzing the answers proposed to the questions, we can see that all the actions are associated with the content of the regulatory manuals. The manuals are nothing more than the Maintenance Organization's way of demonstrating to the Regulatory Authorities how they will comply with the requirements described in the regulations. Ensuring that the company's employees follow the manuals will ensure the requirements are met, thus minimizing or eliminating the risk factors raised.

5. Discussion of Results

When examining Table 4, which outlines the classification of risk factors determining the company's regulatory priorities, it becomes evident that regulation 145.223 deserves primary attention. This item is related to inspections conducted by aircraft authorities, which occur periodically to verify compliance with regulations through regulatory manuals. During the technical visit by the Authority, the assigned inspector assesses the alignment of regulatory manuals with the specified requirements by interviewing staff and inspecting technical areas. Non-compliance with the Aviation Authority's directives could lead to severe consequences, including revoking the current certification, rendering the organization unable to provide maintenance services for clients with aircraft engines registered under the Authority's jurisdiction.

Moreover, the organization may face various sanctions if serious non-conformities are uncovered during inspections. Addressing non-conformities raised during these inspections is crucial, requiring satisfactory responses to rectify potential causes of identified issues. The second and third priorities are items 145.211 (Quality Control System) and 145.207 (Maintenance Organisation Manual). Both items address critical aspects of regulations as the organization communicates its compliance with established requirements to the Aviation Authority through manuals and quality systems. Violations of these requirements directly impact certification, leading to potential revocation as a form of sanction due to non-compliance with fundamental regulatory pillars. It becomes evident that all requirements are essential to the organization. To maintain its certificate, ensure quality, and guarantee Safety for clients, the company must adhere to aviation regulations with excellence. The question presented in Section 1, "What are the critical factors related to non-compliance with regulations?" is answered by examining Table 2. The additional insight in the preceding paragraph emphasizes the importance of complying with all regulatory requirements. As for Question 2, "What actions should be taken to minimize the impact of these risks?" the response is found in Table 6, where actions to respond to risks are outlined. Generally, the organization minimizes the impact of risk by ensuring strict adherence to internal procedures and regulatory manuals. Conducting internal audits, for instance, enables monitoring of organizational actions, allowing the Quality Manager to identify met requirements, pinpoint bottlenecks, and allocate workforce and financial resources effectively.

6. Conclusion

As highlighted in Section 1, aviation regulations play a pivotal role for maintenance organizations by guiding repair and maintenance operations. These regulations ensure the delivery of products that adhere to standards, prioritize Safety and maintain high quality, ultimately meeting customer requirements. The literature review further explores the comprehensive nature of aircraft regulations, spanning various facets of civil aviation to uphold continued airworthiness and flight safety. Section 4 underscores the significance of each regulatory requirement, emphasizing their close classification without any allowance for underestimation. In aviation safety, meticulous attention to every detail is imperative, and compliance with these requirements is foundational. A succinct and robust quality sector can instill a culture of quality throughout the organization, prompting each employee to consider the impact of their actions on product quality and Safety in their operational routines. For future research, it is recommended to investigate the regulatory requirements most frequently violated within the Maintenance Organization. Analyzing non-conformities identified in both external and internal audits can provide insights into the organization's areas of weakness. By understanding these shortcomings, appropriate measures can be taken to minimize errors and mitigate the risks outlined in this study. Ultimately, formulating an action plan to address non-conformities and implement new pro-quality methodologies can yield immeasurable benefits for the organization.

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