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A Comprehensive Review on the Global Aviation Industry and Aircraft Maintenance Management Processes

R. Haluk KUL*, Mehmet ATEŞ**

Abstract

The vision of the Turkish Republic is to surpass the level of contemporary civilization, and one of the main principles to achieve this is "The future is in the skies." To make this a reality, it is imperative to establish a national and domestic aviation industry. The first step towards this goal is to ensure the safe operation of aircraft, which requires a maintenance management system. To create and use the necessary maintenance documents, an international standard management process should be followed for airframe manufacturers and component and part manufacturers in the aviation industry. Airline operators should then create their maintenance documentation according to this system and work with airplane maintenance organizations to ensure the airworthiness of their aircraft. This study discusses and evaluates the documents used within the essential management and organization principles framework, primarily focusing on the aircraft maintenance management system.

Keywords: Aircraft Maintenance, Airworthiness, Airworthiness Documentation, Airworthiness Regulations, Maintenance Inspection

Küresel Havacılık Endüstrisi ve Hava Aracı Bakım Yönetimi Süreçleri İçin Kapsamlı Bir İnceleme

Öz

Türkiye Cumhuriyeti'nin vizyonu muasır medeniyet seviyesini aşmak olup, bunu başarmanın temel ilkelerinden bir tanesi de "İstikbal göklerdedir" şiarıdır. Bunun gerçekleşebilmesi için milli ve yerli havacılık sektörünün kurulması şarttır. Bu hedefe yönelik ilk adım, bakım yönetim sistemi gerektiren hava araçlarının emniyetli bir şekilde çalışmasını sağlamaktır. Havacılık sektöründeki uçak yapısı üreticileri ve komponent ve parça üreticilerine yönelik olarak gerekli bakım dokümanlarının oluşturulabilmesi ve kullanılabilmesi için uluslararası standart bir yönetim sürecinin takip edilmesi gerekmektedir. Havayolu işletmecileri daha sonra bakım dokümantasyonunu bu sisteme göre oluşturmalı ve hava araçlarının uçuşa elverişliliğini sağlamak için hava aracı bakım kuruluşlarıyla birlikte çalışmalıdır. Bu çalışmada, öncelikle hava aracı bakım yönetim sistemi odaklı olmak üzere, temel yönetim ve organizasyon ilkeleri çerçevesinde kullanılan dokümanlar ele alınmakta ve değerlendirilmektedir.

Anahtar Kelimeler: Hava Aracı Bakımı, Uçuşa Elverişlilik, Uçuşa Elverişlilik Dokümantasyonu, Uçuşa Elverişlilik Düzenlemeleri, Bakım Muayenesi

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1. Introduction

In today's world, countries must excel in specific areas to gain a competitive edge in the international environment. Prominent technologies such as aerospace, genetic, and computer technology are crucial.

The Republic of Türkiye's vision, mission, and values were clearly expressed during its founding phase and are encompassed in the phrases "to rise above the level of contemporary civilization," "peace at home, peace in the world," and "the future is in the skies." Despite being one of the dominant technical elements of contemporary civilization, aviation has retained its importance and even increased in significance over the past century.

International cooperation is key to global peace, and "international civil aviation" is one of the most widely utilized.

The Republic of Türkiye has achieved specific successes in civil aviation. However, for a long time, these successes show themselves in business rather than production. Our national airline companies and aircraft maintenance organizations have successfully operated the aircraft used in civil aviation with high reliability and safety after procuring them from manufacturers or other vendors and ensuring airworthiness continuity. To achieve this success, the following steps must be completed successfully:

Establishing an accurate maintenance management system using documentation from aircraft manufacturers, civil aviation authorities, and manufacturing organizations. Performing complete and flawless aircraft maintenance within the structure of the airline itself and in aircraft maintenance organizations, according to the plans obtained in this system.

Significant projects have been initiated in our country and are continuing at various aircraft production levels. Apart from these large projects, the design, production, sale, and use of relatively small-sized aircraft, especially aircraft that can be used in general aviation, will greatly benefit our country. At this stage, there is a need for knowledge that can provide aircraft maintenance documentation and proper and complete maintenance management to aircraft operators in the aircraft manufacturing sector and suppliers in Türkiye.

It's important to first define the management concept to understand maintenance management processes. The management can be defined as "The process of making and implementing decisions that efficiently and effectively utilize financial resources, equipment, fixtures, raw materials, auxiliary materials, and time to achieve certain goals." (Eren, 2011).

To meet this requirement, various types of documentation are used in civil aircraft maintenance management at an international level. These documents are created through specific processes, including maintenance planning output, designer and manufacturer collaboration, and cooperation with aircraft components or part suppliers and operators.

This study examines these aircraft maintenance processes and the documents used for them. It will evaluate the production process of the documents that manufacturers create for aircraft maintenance and make suggestions on how to disseminate information about the documentation process to manufacturers and suppliers across the country.

2. Material and Method

Aircraft maintenance refers to ensuring that an aircraft is safe and fit for flying by conducting various activities such as inspection, repair, modification, overhaul, and servicing. Aviation authorities regulate airplane maintenance, which follows a recognized maintenance program for each aircraft type.

2.1. Basic Concepts of Maintenance Management

This section provides a list of concepts related to aircraft maintenance management and documentation, along with their respective definitions and descriptions.

Maintenance management is a critical aspect of the aviation industry. It involves planning and executing maintenance tasks to ensure the safety and airworthiness of aircraft. It is a challenging but necessary process that guarantees the safety of passengers and crew and the consistent and reliable operation of airplanes.

Given the increasing demand for air travel and the intense scrutiny in the aviation sector, maintaining planes to the highest standard is crucial. Therefore, it is essential for everyone working in the aviation business to understand the fundamentals of maintenance management.

This chapter will detail the essential ideas and procedures of maintenance management in the aviation sector, including its significance, challenges, and recommended procedures for productive and successful maintenance operations.

- ***Acknowledged (Approved) School:*** The demand for highly qualified and informed people in the aviation industry is constantly growing. Consequently, the aviation sector has instituted stringent guidelines and prerequisites for pursuing careers in this domain. To be considered a certified aviation professional, one of the essential requirements is to complete an accredited program. It is a mark of distinction and evidence of the school's capacity to offer future aviation professionals a first-rate education and training program. In this paragraph, the value of an accredited school in the aviation sector, along with the advantages it presents to students who want to work in this fascinating business, will be discussed. It is a training institution given by the General Directorate of Civil Aviation of the Republic of Türkiye, where it is stated within the framework of an accreditation system that the training activities comply with the rules of SHT-66 and SHT-147.
- ***Administration Roles:*** Mintzberg and friends (Mintzberg et al., 1976) suggest ten different roles, which are grouped into three groups: interpersonal roles, informatics roles, and decision-oriented roles.
- ***Aircraft:*** According to the definition given in the SHY-RAMP regulation, an aircraft is defined as "Any vehicle that can take off and can navigate in the air (SHY-RAMP).
- ***Aircraft / Airframe Manufacturer:*** It is the organization that produces the aircraft by bringing together the parts or components that the aircraft produces in its facilities or the parts or components produced by the suppliers.
- ***Aircraft Flying with Aerodynamic Lifting:*** Aircraft are vehicles that can oppose the force of gravity with a phenomenon called grip and can be used for transportation in this way. Fixed or rotary-wing aircraft can be an example, using the aerodynamic bearing force created by the moving parts against the gravitational force. Examples include airplanes, gliders, and helicopters. To counter gravity in such aircraft, the blades in fixed-wing aircraft and the propellers in rotary-wing aircraft must be constantly in motion.

- ***Aircraft Flying with Aerostatic Buoyancy:*** The aviation industry has been using aircraft that fly using aerostatic buoyancy, like balloons, for centuries. The Montgolfier brothers conducted their first experiments in France in the 1780s to lift objects and achieve flight using gasses lighter than air. Since then, balloons have been utilized for various applications, including leisure and scientific studies. Balloons are used mainly in aviation for events, tourist trips, aerial photography, and advertising. Although they might not be utilized as frequently as conventional airplanes, balloon rides give travelers an exceptional and unforgettable flying experience. Because aerostatic buoyant aircraft don't burn fuel or emit emissions while in flight, they provide a more economical and sustainable option to standard airliners. Balloons play a significant role in aviation, providing pilots and passengers with unique viewpoints and experiences. Aerostatics is obtained because the density of the gas in a specific volume is less than the air in an aircraft that does not have wings other than the aircraft classified above. Thanks to the lift, the force of gravity is countered. Examples include balloons, blimps, and airships.
- ***Aircraft Maintenance Organization:*** The vital component of the aviation sector, Aircraft Maintenance Organizations (AMOs) are in charge of guaranteeing the aircraft's airworthiness and safety. These institutions are essential to the general safety of air travel and the daily operations of airlines. Aircraft maintenance and upkeep are intricate, strictly regulated processes that require specific knowledge and abilities. AMOs are essential aviation industry members, handling everything from minor repairs and annual inspections to extensive overhauls and changes. AMOs must follow stringent guidelines and standards in this rapidly changing business to guarantee the effectiveness and safety of aircraft. These organizations play a crucial role in maintaining the seamless operation of the aviation industry since air travel safety and dependability would be jeopardized without them. In this essay, we shall go more deeply into the realm of AMOs, looking at their roles, rules, and significance in preserving the integrity and safety of the aviation sector. They are organizations that can perform all kinds of authorized maintenance and repair operations, such as base and line maintenance for aircraft. These organizations are also called Maintenance Repair and Overhaul (MRO) organizations.
- ***Airline Management:*** Businesses that carry passengers, cargo, or passengers and cargo for commercial purposes on certain lines with air vehicles for a fee, passenger and cargo transportation that is not within the scope of commercial air transportation, and businesses that carry out aerial work and training activities regardless of whether they are paid or not are considered air transportation enterprises (SHGM, Air Transport Enterprises).
- ***Airworthiness*** means that the aircraft, engine, propeller, part, or device is in compliance with a type certificate accepted by the Country Airworthiness Authority (CAA) or approved design data and in a safe operation condition (SHY-CA). As Figure 1 shows, there is a hierarchical relationship between the United Nations (UN), the International Civil Aviation Organization (ICAO), and CAAs.

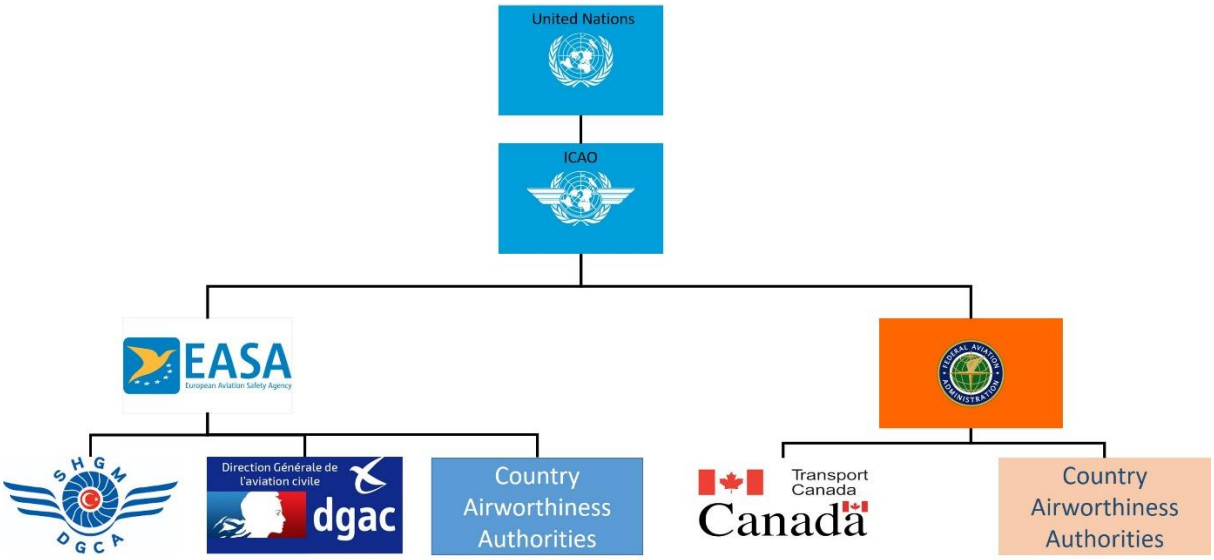

Figure 1. The Hierarchical Relation Between UN, ICAO, and CAAs (Saraçyakupoğlu, 2020)

Airworthiness is a crucial concept in the aviation industry that refers to an aircraft's ability to fly safely and maintain its structural integrity while in flight. It encompasses different aspects, such as the aircraft's design, production, maintenance, and operation. Before aviation authorities can certify an aircraft for flight, its airworthiness must be established through rigorous testing and evaluation of its systems, components, and overall structure. Airworthiness is an ongoing process, as an aircraft must undergo regular maintenance and inspections to ensure it remains safe to fly. The safety and security of passengers, crew, and the general public depend on proper airworthiness. Without it, an aircraft may encounter technical failures and other issues that can result in accidents. Therefore, ensuring an aircraft's airworthiness is continuously monitored and maintained to the highest standards is a crucial responsibility for aviation experts.

- ***Airworthiness Certificate:*** An aircraft may not be operated without a valid airworthiness certificate (Saraçyakupoğlu, 2020). The airworthiness certificate is issued when the applicant demonstrates that the aircraft conforms to the type design approved by the type certificate. The relevant documentation, inspection, and tests show that the aircraft is in suitable conditions for safe operation. The airworthiness certificate is valid as long as it is not suspended or canceled by the General Directorate and the continuous airworthiness of the aircraft is maintained (SHGM).
- ***Airworthiness Directive (AD):*** Airworthiness Directives are legally binding requirements that aircraft owners and operators must adhere to to maintain the airworthiness of their aircraft. Aviation authorities, such as the Federal Aviation Administration (FAA) in the United States, issue these directives after identifying potential safety issues with particular aircraft models or components. The goal of an Airworthiness Directive is to prevent accidents and incidents by mandating specific actions, such as inspections, repairs, or modifications, that must be taken within a specified time frame. Failure to comply with an Airworthiness Directive can result in penalties and even the grounding of the affected aircraft. Manufacturers of aircraft and aircraft components also have a responsibility to address safety issues and issue relevant service bulletins or modified parts to ensure compliance with Airworthiness Directives. Overall,

these directives are critical in maintaining the safety and airworthiness of aircraft, ultimately protecting the lives of passengers and crew onboard.

Annex: The annexes set out the Standards and Recommended Practices (SARPs) expected from States that have signed the ICAO convention. They detail SARPs and provide insight into what and how States must do to achieve them. Establishing and maintaining International SARPs and Air Navigation Procedures (PANS) are core principles of the Convention on International Civil Aviation - the Chicago Convention - and a fundamental aspect of ICAO's mission and role (The Convention on International Civil Aviation Annexes 1 to 18). The ICAO Annexes are provided in Table 1.

Annex	**Description**
Annex 1	Personnel Licensing
Annex 2	Rules of the air
Annex 3	Meteorological Service for International Air Navigation
Annex 4	Aeronautical Charts
Annex 5	Units of Measurement to be Used in Air and Ground Operations
Annex 6	Operation of Aircraft
Annex 7	Aircraft Nationality and Registration Marks
Annex 8	Airworthiness of Aircraft
Annex 9	Facilitation
Annex 10	Aeronautical Telecommunications – Digital Data Communication Systems
Annex 11	Air Traffic Services
Annex 12	Search and Rescue
Annex 13	Aircraft Accident and Incident Investigations
Annex 14	Aerodromes – Aerodrome Design and Operations, Heliports
Annex 15	Aeronautical Information Services
Annex 16	Environmental Protection – Aircraft Noise
Annex 17	Security: Safeguarding International Civil Aviation against Acts of Unlawful Interference
Annex 18	Safe Transport of Dangerous Goods by Air
Annex 19	Safety Management System

Table 1. ICAO Annex List

ATA 100 Chapters: The Air Transport Association, or ATA, was first established in 1936 as a trade association representing American airlines. The ATA 100 specification is a naming and numbering scheme for aviation systems developed by ATA in 1956. The idea was to create a

uniform vocabulary and classification scheme for technical data so that various aircraft manufacturers could work together and communicate more easily. Nine chapters, covering everything from engine systems to airframe systems, made up the first edition of ATA 100. The complexity of the industry and the variety of aircraft designs and technologies have grown. ATA updated the specifications regularly; the most recent version is ATA Spec 100, published in 2014. This version includes 328 chapters illustrating a particular aircraft system or part, like the fuel, hydraulic, and electrical systems. The chapters are arranged in a hierarchical structure, with the overall description of the aircraft and its systems represented by the first level, which has numbers 01 through 14. The ATA chapters about the airframe and its systems are represented by the second level, which has numbers 21 through 49. The engine and propulsion systems are covered in the third level, numbered 51 to 99. The maintenance methods and processes are described in the fourth level, which spans 101 to 130 (Saraçyakupoğlu, 2020).

The main aircraft manufacturers, including Boeing, Airbus, and Bombardier, have widely accepted and implemented the structure and numbering of ATA 100 chapters. With the support of regulatory agencies like the ICAO, the European Aviation Safety Agency (EASA), and the Federal Aviation Administration (FAA), it has also evolved into a worldwide standard. ATA 100 chapters support ongoing maintenance task tracking and monitoring, which enables prompt and effective aircraft maintenance. Ultimately, this guarantees that airplanes are in the best shape for safe flight. Nevertheless, using ATA 100 chapters has drawbacks and many advantages. Among these is the ongoing requirement for modifications and updates to stay up with the quickly advancing field of aviation technology. Every new aircraft design or modification necessitates the addition of new ATA chapters as well as the revision of current ones. This can cost manufacturers and operators money and take a lot of effort.

- ***Six Sigma Level Error Management:*** Six Sigma is a data-driven quality management methodology that enhances processes by locating and eliminating errors down to 3.4 defects per million chances. The fundamental tenet of the Six Sigma methodology is that statistical fluctuations are a part of any process and can be minimized and managed by applying data-driven methods. This strategy is used in aviation to lower error rates and boost dependability and safety. It is the accepted level of risk in both maintenance activities and flight operation activities in aviation. Additionally, Six Sigma encourages a continuous improvement culture in the aviation sector. It promotes evidence-based decision-making through data-driven methodologies, which results in more productive and successful operations.

Consequently, this raises customer satisfaction and the industry's overall success. In addition, Six Sigma offers an organized method for handling errors by ensuring protocols and guidelines are clear and regularly followed, lowering the likelihood of mistakes. This is particularly crucial in high-risk fields like airplane repair, where errors can have catastrophic repercussions.

Delta Airlines is one instance of a successful Six Sigma implementation in the aviation sector. Delta Airlines had to deal with high fuel prices and an older fleet of aircraft in the early 2000s, which led to expensive maintenance bills and delayed flights. Delta Airlines adopted the Six Sigma approach to enhance its operations, resulting in notable performance gains. Maintenance expenditures dropped by 10% in three years, and on-time performance rose from 70% to 85%. As a result, the company's overall costs were reduced by $1 billion. Other airlines have used Six Sigma to enhance their performance due to Delta Airlines' well-known implementation of the methodology.

- ***The Concept of Maintenance in the Aviation Industry:*** Ensuring the safety and dependability of aircraft is crucial for all parties involved, such as airlines, regulatory agencies, and passengers (Saraçyakupoğlu, 2021). Maintenance is essential to guarantee the aircraft's safe and effective functioning. In aviation, maintenance is a thorough and organized procedure involving various tasks like inspecting, repairing, overhauling, and altering aircraft and its parts (Saraçyakupoğlu & Ateş, 2021). The notion of maintenance in the aviation business, its importance, and its effects on airline operations will all be covered in this essay.

Maintenance is a systematic, ongoing procedure that attempts to maintain an aircraft's airworthiness in the aviation sector. When an aircraft is considered airworthy, it is free from flaws that could compromise its performance or safety and can fly as intended. An aircraft's ability to carry passengers and cargo, as well as the airline's reputation, depends on it being airworthy. Improper maintenance of an airplane can have serious repercussions, such as crashes, fatalities, or property damage.

Preventive maintenance is the foundation upon which the aviation industry bases its notion of maintenance. This implies that rather than waiting for parts to break, maintenance is done on a planned basis. This method assists in locating and resolving possible problems before they cause a malfunction or breakdown. Line maintenance, base maintenance, and overhaul are the primary categories into which maintenance tasks fall. The flight crew performs routine inspections and minor repairs during line maintenance, which happens in between flights. An overhaul is an aircraft's total disassembly and rebuilding, while base maintenance entails a more thorough inspection and repair of individual aircraft parts.

Keeping aircraft airworthy also greatly impacts passengers' safety and comfort. Travelers anticipate arriving at their destinations promptly and safely, and the aircraft's dependability is essential to meeting this expectation. Regular maintenance helps airlines find and fix possible problems with an aircraft, which lowers the chance of mechanical problems causing delays and cancellations.

2.2. The Conceptual Definitions Regarding Maintenance in the Aviation Industry

Maintenance in the aviation industry is a systematic process that involves inspecting, repairing, and servicing aircraft to ensure their safe and efficient operation. It encompasses all actions necessary to keep an aircraft airworthy, from routine checks and minor repairs to major overhauls and upgrades. This chapter aims to provide valuable insights into the aviation industry's fundamental maintenance principles.

- ***Aircraft Maintenance Training Organization:*** Aircraft Maintenance Training Organizations (AMTOs) are essential in maintaining the safety and reliability of aircraft. These organizations offer rigorous training programs that equip individuals with the skills and knowledge necessary to pursue a career in aircraft maintenance. From the fundamentals of aircraft maintenance to advanced troubleshooting techniques, AMTOs provide comprehensive training focusing on the latest technological advancements in the aviation industry and the importance of adhering to strict safety regulations and procedures. The demand for skilled aircraft maintenance technicians has also increased, with the aviation industry continuously expanding. This has made AMTOs even more critical, as they play a crucial role in ensuring the industry's success by producing skilled and knowledgeable individuals who will maintain, repair, and troubleshoot various types of aircraft.

- ***Maintenance Review Board (MRB):*** The Maintenance Review Board (MRB) is a systematic and organized process for overseeing the creation, approval, and execution of aviation maintenance plans. It involves a team of industry experts, manufacturers, and operators who evaluate and analyze maintenance tasks and data to determine the most effective and economical approach to maintaining an aircraft. The Federal Aviation Administration (FAA) proposed the idea of MRB in the late 1960s to address the need for a standardized method of aircraft maintenance across the industry. MRB aims to reduce overall maintenance costs by eliminating unnecessary and redundant maintenance procedures. This ensures safe and reliable aircraft operations, enabling the aircraft to perform at its best (Orhan, 2022).
- ***Maintenance Review Board Report (MRBR):*** The Maintenance Review Board is a team led by the Airworthiness Authority. This group determines the guidelines for creating a Maintenance Program for an aircraft or an aircraft engine type. They do this by issuing a Maintenance Review Board Report (MRBR). Additional MRBRs are released occasionally to ensure that approved maintenance procedures continue to fully address aircraft modifications and variations throughout the aircraft's lifespan.

The first step in the MRB process is creating the MRBR, a comprehensive document that outlines the maintenance requirements for a particular aircraft. The manufacturer is responsible for creating this document, which is continuously updated based on feedback from operators, regulatory agencies, and market trends (Ateş, 202).

- ***Maintenance Planning Document (MPD):*** It's the maintenance plan the aircraft manufacturer developed for their aircraft model after its use. This plan is highly recommended to the aircraft model operators. The document, known as the Maintenance Planning Document (MPD), includes all the Maintenance Review Board (MRB) requirements and mandatory scheduled maintenance requirements. It's important to note that these requirements are not easily changed and require permission from the relevant airworthiness authority. Overall, this document is a valuable resource that can aid in aircraft's safe and effective operation (Lapesa, 2022).
- ***Maintenance Program (MP):*** Creating and implementing an aircraft maintenance program is crucial for ensuring the safety and continued airworthiness of the aircraft. The program is developed by the aircraft operator or owner based on the maintenance planning document, which takes into account various factors such as configuration, flight time, landing-take-off number, and age of the aircraft. The civil aviation authority of the state of registration carefully reviews and approves the program before it goes into effect. Following the maintenance program, the operator can perform necessary maintenance tasks and keep the aircraft in top condition for safe and efficient operation (Saraçyakupoğlu, 2020) (Kinnison , 2013).
- ***Maintenance Types - By the location of maintenance:*** Understanding the various types of maintenance is important to keep an aircraft in good condition. Maintenance can be classified based on where it is performed. Line maintenance is performed on the apron while the aircraft is in service. Base maintenance is carried out in the closed area of the aircraft's maintenance facility. Other facility units perform Workshop maintenance on the components or parts removed from the aircraft. By recognizing these different types of maintenance, aircraft owners and operators can ensure that their aircraft is safe and properly maintained (Saraçyakupoğlu 2020) (Kinnison 2013).
- ***Maintenance Types - By Period Types:*** Certain maintenance procedures are dependent on the amount of time an aircraft spends in the air, also known as flight time. Other maintenance

procedures are based on the number of take-offs and landings, also known as flight cycles. Finally, some maintenance procedures are performed according to a specific period, regardless of the time or cycle the aircraft has flown (Saraçyakupoğlu 2020) (Kinnison 2013).

- ***Maintenance Steering Group (MSG):*** The Maintenance Steering Group (MSG) developed a document called MSG-3, which stands for "Operator/Manufacturer Planned Maintenance Development". This document was created by the Federal Aviation Administration (FAA) for airlines and provides a methodology for developing scheduled maintenance tasks and intervals. The goal of MSG-3 is to create a maintenance plan that is efficient and recognized by regulatory authorities, operators, and manufacturers. This is achieved by recognizing the inherent reliability of aircraft systems and components and avoiding unnecessary maintenance tasks.
- ***Safety, Reliability, Security:*** Safety refers to the state of being free from accidents, serious incidents, hazards, and other factors that could lead to unfavorable outcomes. This is achieved by adhering to regulations set by authorities and avoiding mistakes and violations (Stosic, Dahlstorm & Boonchai, 2023). Reliability, on the other hand, is the ability of a product to perform its expected functions successfully for a specified period under defined operational conditions. Security involves measures states or organizations take to prevent incidents such as sabotage, attack, espionage, and theft. These measures aim to protect individuals and property from harm and ensure a safe and secure environment (Gerede, 2006).
- ***Airline Management:*** Companies that transport passengers or cargo for a fee using air vehicles on specific routes are known as commercial air transportation businesses. Companies that transport passengers and cargo that are not part of commercial air transportation and engage in aerial work and training activities, whether paid or not, are also classified as air transportation enterprises.

3. Conclusions and Discussions

Starting from the conceptual design of the aircraft, following the prototype production and test flights, after obtaining the type certification and then obtaining the production license, aircraft manufacturers begin the production of aircraft at their production facilities for their customers. After the aircraft is delivered to the customer, the aircraft is started to be used in flight operations by the operator organization. From this stage onwards, ensuring that the relevant aircraft is always airworthy is necessary. While the manufacturer is responsible for ensuring that an aircraft is airworthy when delivered from the factory, this responsibility passes on to the owner and/or operator company after delivery.

To ensure that the aircraft they use are continuously airworthy, airline operators in aircraft maintenance organizations ensure that their vehicles' pre-determined and approved maintenance operations have the competencies according to the determined criteria. These operations should be performed by maintenance personnel whose competencies are approved in terms of knowledge, skills, and experience. The abovementioned processes constitute sub-components of the main aircraft maintenance management process.

The documentation of the maintenance operations to be done for an aircraft has a process consisting of five stages (Kinnison & Siddiqui, 2013). In the first step of the aircraft maintenance management process, the designer and the manufacturer come together with the component or part manufacturers and possible airline companies to form the Maintenance Review Board (Maintenance Review Board-MRB). At this stage, the Maintenance Steering Group (MSG) can carry out the work related to the maintenance planning of the relevant board. Maintenance planning is carried out using the MSG-3 approach for the aircraft being produced today (Kearns,

2021). This board proposes a first-level maintenance review. The stated board prepares the Review Board Proposal /MRBP) document. In the second phase, the same board has prepared the Maintenance Review Board Report" as a list of initial guidelines in maintenance activities for businesses that have purchased and started operating the aircraft for the first time. Prepares Review Board Report / MRBR). The manufacturer delivers this document to the operators during the first deliveries. Considering these suggestions, the aircraft manufacturer organization creates the Maintenance Planning Document (MPD) and delivers it to the operators. Maintenance Planning Document is an advisory document. It is an initial step for preparing Maintenance Program. The Continuous Airworthiness Management Organisation preparers the Maintenance Program by using the data given in the MPD, operation policy and operation conditions of the aircraft. The maintenance program must be approved by the Civil Aviation authority. The last step of this process is keeping up to date of the program by integrating Airworthiness Directives, Service Bulletins, and Engineering Orders as needed.

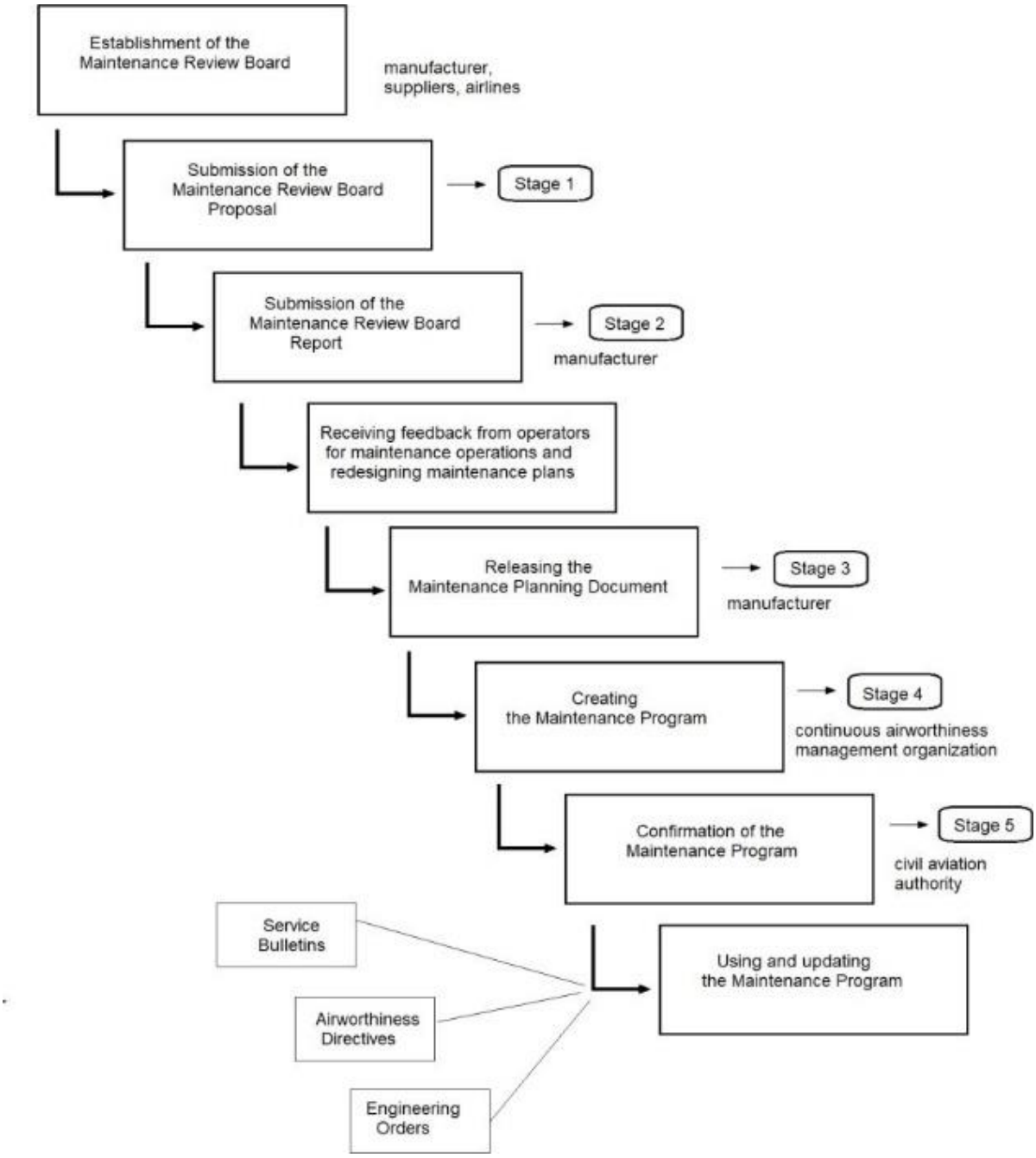

Figure 2. Aircraft Maintenance Program Development and Implementation Process (Saraçyakupoğlu 2020) (Kinnison 2013) (Kearns 2021) (Koizum 2023)

In aircraft maintenance management, the interdependence of airworthiness, flight safety, quality control, and documentation is critical. An aircraft's airworthiness is a gauge of how safe it is to fly, and the aviation maintenance crew is mostly in charge of ensuring that all systems and parts meet safety regulations. On the other hand, flight safety takes a more comprehensive approach and concentrates on detecting and reducing possible dangers to prevent accidents and incidents. With an emphasis on continual improvement, quality management is a systematic way to guarantee that maintenance chores are completed to the highest standards. In addition to

guaranteeing regulatory compliance, proper documentation documents all maintenance actions and provides vital information for the next maintenance.

Every element that goes into building a safe and effective aviation maintenance management system is interdependent and essential. The safety of the passengers and the aircraft may be jeopardized if any of these components are absent, putting the system in danger. Consequently, to maintain the highest levels of safety and airworthiness, specialists in aviation maintenance management must prioritize integrating these components and recognize their relevance.

3.1. The Relationship of Airworthiness, Flight Safety, Quality Management and Documentation in Aircraft Maintenance Management

- In the case of the operation of an aircraft, this flight should be safe and trouble-free and arrive at the destination airport in a timely manner. The primary concern here is safety. Airworthiness is the state of being confident that an aircraft will fly safely with an acceptable level of risk at the start of each flight. The aircraft operator should always ensure that the aircraft it is responsible for is airworthy, which is the sustainability of airworthiness. It must establish and operate a maintenance system to maintain airworthiness. It should ensure that the operations carried out in this maintenance system, including all three definitions of quality, will ensure safety and maintain airworthiness. These requirements also require a quality management system and documentation system. Three different definitions of quality can be examined in this context:
- Quality is to comply with the specifications,
- Quality is fitness for use,
- Quality is meeting the expectations and needs of the customer
- In aviation, it is to comply with the technical quality specifications due to the "safety first" motto. Therefore, national-institutional adaptation is required within the framework of the norms hierarchy of the specifications, from global to national. In this context, it must be adapted to fit Weber's ideal bureaucracy. Within the framework of this principle, in order to be sure that every activity will be safe, the Maintenance of Aircraft must be carried out completely and without errors. In this context, in terms of Statistical Quality Management, the goal in aviation is full competence at the "Six Sigma " level and beyond (Panagopoulos, Atkin Sikora, 2006).

In this study, information will be given on implementing operations with almost zero error in the Aircraft Maintenance Management organization and the Processes and Documentation System Applied for Continuous Airworthiness. A road map proposal will be presented in which the ways to be followed for the development of the civil aviation industry in Türkiye can be discussed. Since civil aviation takes place on an international scale, it will be useful to examine institutions and organizations, starting from the International Aviation Organization, to understand and implement the hierarchy of norms.

3.2. 2. Organization of Maintenance Management and Legal Basis in International Civil Aviation

After considering the definition of the word organization according to two different approaches and deciding which of these definitions would be more appropriate for aviation, it would be useful to examine the aircraft maintenance management organization.

Below are the "technical definition" and "behavioral definition" for the organization:

According to the Technical Definition, the organization processes the resources it receives from the environment from outside its system and presents the values it processes to the environment as output. It is a stable formal and social structure. Within the framework of this definition, the organization provides goods and services using labor, capital, and raw materials. In the technical definition, the human factor has been disabled for the organization, which may lead to inadequacies in its use by aviation organizations. According to the behavioral definition, organization is the structure that emerges from balancing rights, priorities, obligations, and responsibilities over time through conflict and conflict management (Kul 2013).

The behavioral definition provides a more accurate context for aviation institutions and organizations. In aviation, human beings are not only considered resources as stated in classical management functions, but also important factors in Module 9, Human Factors, which is one of the main module contents (DGCA SHT-66) (Saraçyakupoğlu 2016).

For maintenance management, different organizations along the industrial chain and the continuity of efficient, effective, and error-free service production will be needed in the interaction of these organizations. Therefore, quality management should be applied in maintenance management. Therefore, every aviation organization should have a quality policy, procedures, and manuals stating it (Ateş, Kul & Düzgün, 2019).

To the content of the maintenance packages in which maintenance activities are created in maintenance management and the unique configuration of each aircraft, aircraft maintenance organizations require adhocratic organization within Mintzberg's organization types classification, on the one hand, and professional organization due to the semi-structural decisions made by specialists, especially in troubleshooting (Kul 2013) (Ateş, Kul & Düzgün, 2019). In particular, the workload of letter maintenance, service bulletins, and airworthiness directives, which will be defined in the later stages of the article, requires a project management approach. Spreading project management practices and culture in aviation organizations and using a matrix organizational structure would be the right approach. Maintenance operations involving short-term periods also require an organizational structure that includes mechanized bureaucracy and routine and repetitive workloads.

Quality management is at the center of managerial activities in aviation. It includes safety and security management, critical in all activities (Gerede, 2006). Special processes and procedures are required for aviation activities' effective, efficient, and error-free operation. They must be documented, accessed, and implemented by the right people.

As indicated in Figure 3, examining an aircraft maintenance organization on basically two focuses would be correct. Aircraft maintenance organizations are generally for-profit organizations; therefore, they are expected to fulfill the basic business functions that should be carried out in every common business (Cardeal, Hose, Riveiro & Gotze, 2020). Although "Maintenance procedures to ensure continuity of airworthiness for aircraft" are prominent, the provision of correct and sufficient human resources, the acquisition of the right facilities and equipment, and the financial resources required to provide accurate and up-to-date data are prerequisites. Apart from this, it is necessary to perform the sales and marketing function to promote and sell the product to potential customers for the service provided.

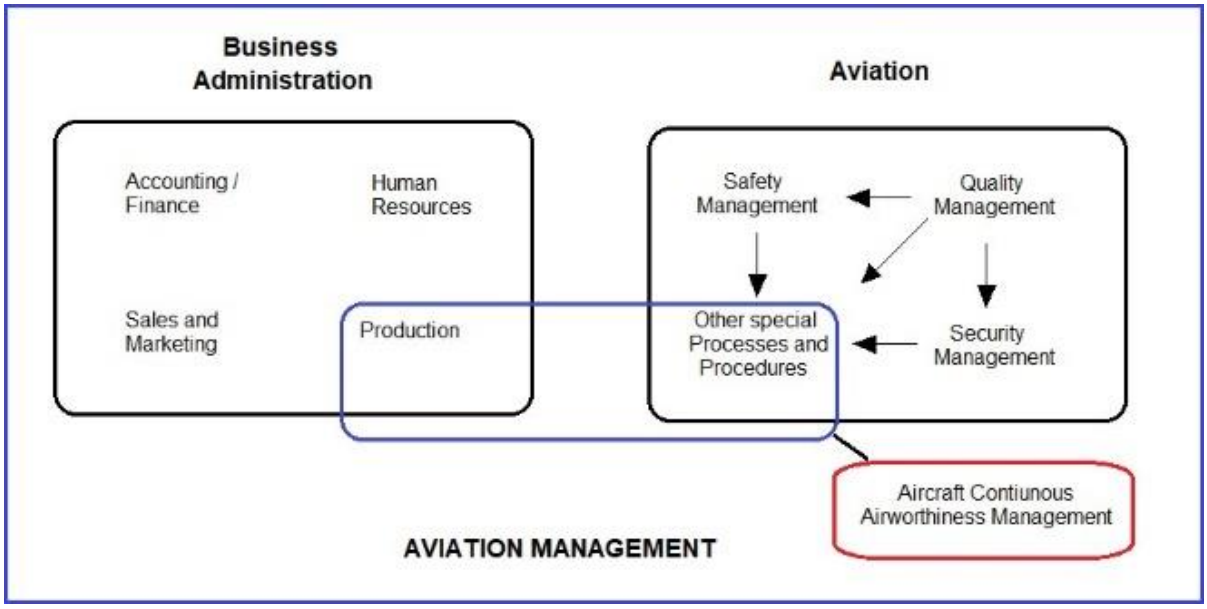

Figure 3. Interaction of Business Management and Aviation Processes (The Graphic was Re-Illustrated the information based on the Author's knowledge

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Author Contributions

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Conflict

The authors declare no conflict of interest

Data Availability Statements

The datasets used or analyzed during the current study are available from the corresponding author upon reasonable request.

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APPENDIX: NOMENCLATURE

AD	Airworthiness Directive
AMM	Aircraft Maintenance Manual
AMTO	Aircraft Maintenance Training Organizations
CAA	Country Airworthiness Authority
CofA	Certificate of Airworthiness
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
ICAO	International Civil Aviation Organization
MPD	Maintenance Planning Document
MP	Maintenance Program
MRB	Maintenance Review Board:
MRBR	Maintenance Review Board Report
MSG	Maintenance Steering Group
SARP	Standards and Recommended Practices
UN	United Nations