AIRCRAFT MAINTENANCE SAFETY - HAND TOOLS USAGE ON MAINTENANCE PROCESSES

Master’s Degree Thesis

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MASTER'S DEGREE THESIS

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Program in Civil Aviation Management (Turkish)
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Eskişehir
Anadolu University
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JÜRİ VE ENSTİTÜ ONAYI

Muhammad Noor HAYEK'ın ''Aircraft Maintenance Safety - Hand Tools Usage on Maintenance Processes'' başlıklı tezi **27 Ekim 2021** tarihinde, aşağıdaki jüri tarafından Lisansüstü Eğitim-Öğretim ve Sınav Yönetmeliğinin ilgili maddeleri uyarınca toplanan **Sivil Havacılık Yönetimi Anabilim Dalı nda, yüksek lisans tezi** olarak değerlendirilerek kabul edilmiştir.

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ABSTRACT

Aircraft Maintenance Safety - Hand Tools Usage on Maintenance Processes
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Anadolu University, Social Sciences Institute, October 2021
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Aircraft maintenance is a vital process that keeps aircrafts airworthy through such inevitable sophisticated and expensive processes that keeps them flyable. The enormous volume and significant importance of such a business necessitated its regulation by international organizations. Yet, studies have shown that there is still a gap between this industry and the different parties involved in it especially maintenance technicians and their roles in making reliable maintenance through a unique use of maintenance hand tools. In this scope, it is believed that this issue can be addressed by creating a code of conduct of the committed use of maintenance hand tools.

The main purpose of this research is to suggest solutions for today's aircraft maintenance programs becoming more costly, time consuming and hand tools damaging. It is predicted that the proposed code of conduct will put an end to such an issue through identifying the different factors leading to it. In this scope and to collect the data, a survey has been presented to dozens of aircraft maintenance technicians of different departments and experience. Later on, a quantitative research has been made to investigate the issues that the maintenance staff have and the challenges that face this industry As a result, all different factors that can lead to this problem have been determined and a thorough code of conduct has been proposed. It is believed that this research will lead to a higher maintenance technicians' productivity and more cost-saving ones.

Keywords: Aircraft Maintenance Programs, Quantitative Research, Maintenance Procedures, Maintenance Challenges and Optimization.

ÖZET

Uçak Bakım Güvenliği - Bakım İşlemlerinde El Aletleri Kullanımı

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Sivil Havacılık Yönetimi Bölümü

Anadolu Üniversitesi, Sosyal Bilimler Enstitüsü, Ekim 2021

Danışman: Doç. Dr. Savaş S. ATEŞ

Uçak bakımı, uçakları uçabilir kılan bu kadar kaçınılmaz karmaşık ve pahalı süreçlerle uçuşa elverişli tutan hayati bir süreçtir. Böyle bir işin muazzam hacmi ve önemi, uluslararası kuruluşlar tarafından düzenlenmesini gerektiriyordu. Yine de çalışmalar, bu endüstri ile bu endüstride yer alan farklı taraflar arasında, özellikle bakım teknisyenleri ve benzersiz bir bakım el aletleri kullanımı yoluyla güvenilir bakım yapmadaki rolleri arasında hala bir boşluk olduğunu göstermiştir. Bu kapsamda, bakım el aletlerinin taahhütlü kullanımına ilişkin davranış kuralları oluşturularak bu konunun ele alınabileceği düşünülmektedir.

Bu araştırmanın temel amacı, günümüz uçak bakım programlarının daha maliyetli, zaman alıcı ve el aletlerine zarar veren hale gelmesine yönelik çözüm önerileri sunmaktır. Önerilen davranış kurallarının, buna neden olan farklı faktörleri belirleyerek böyle bir soruna son vereceği öngörülmektedir. Bu kapsamda ve verilerin toplanması için farklı departman ve deneyime sahip onlarca uçak bakım teknisyenine anket sunulmuştur. Daha sonra, bakım personelinin sahip olduğu sorunları ve bu endüstrinin karşılaştığı zorlukları araştırmak için nicel bir araştırma yapılmıştır. Sonuç olarak, bu soruna yol açabilecek tüm farklı faktörler belirlenmiş ve kapsamlı bir davranış kuralları önerilmiştir. . Bu araştırmanın daha yüksek bakım teknisyenlerinin verimliliğine ve daha maliyet tasarrufu sağlayanlara yol açacağına inanılmaktadır.

Anahtar Kelimeler: Uçak Bakım Programları, Nicel Araştırma, Bakım Prosedürleri, Bakım Zorlukları ve Optimizasyon.

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I would like to sincerely thank everyone who stand by me through my academic studies. My family, friends and colleagues, thank you from my deepest heart. In addition, I would like to thank Dr. Savaş S. ATEŞ for his generous support and unique guidance. Moreover, I would like to thank the academic staff at Anadolu University for their personal and academic love and support they have shown during my postgraduate studies over there. Finally, I would sincerely like to thank the European Union for its generosity for supporting my studies through the scheme of Turkish Scholarships – YTB. To all of these people, I could not have done my program without your support. Thank You!

01/10/2021

DECLARATION OF COMPLIANCE WITH ETHICAL PRINCIPLES AND RULES

This thesis is my own, original work; I have acted in accordance with scientific ethical principles and rules at all stages of my study, including preparation, data collection, analysis and presentation of information; that I have cited all data and information obtained within the scope of this study and that I have included these sources in the bibliography; I declare that this study has been screened with the "scientific plagiarism detection program" used by Anadolu University and that it does not "contain plagiarism" in any way. At any time, I declare that I accept all moral and legal consequences that may arise in the event of any violation of this statement regarding my work.

....

(Signature)

Muhammad Noor Hayek

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01/10/2021

ETİK İLKE VE KURALLARA UYGUNLUK BEYANNAMESİ

Bu tezin bana ait, özgün bir çalışma olduğunu; çalışmamın hazırlık, veri toplama, analiz ve bilgilerin sunumu olmak üzere tüm aşamalarında bilimsel etik ilke ve kurallara uygun davrandığımı; bu çalışma kapsamında elde edilen tüm veri ve bilgiler için kaynak gösterdiğimi ve bu kaynaklara kaynakçada yer verdiğimi; bu çalışmanın Anadolu Üniversitesi tarafından kullanılan "bilimsel intihal tespit programı"yla tarandığını ve hiçbir şekilde "intihal içermediğini" beyan ederim. Herhangi bir zamanda, çalışmamla ilgili yaptığım bu beyana aykırı bir durumun saptanması durumunda, ortaya çıkacak tüm ahlaki ve hukuki sonuçları kabul ettiğimi bildiririm.

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(İmza)

Muhammad Noor Hayek

(Öğrencinin Adı Soyadı)

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ACRONYMS INDEX

A/P: Alternative Parts

AI: Artificial Intelligence

AMP: Aircraft Maintenace Personnel

AMTS: Aviation Maintenance Technician School

APU: Auxiliary Power Unit

AR: Augmented Reality

EASA: European Union Aviation Safety Agency

FAA: Federal Aviation Administration

IATA: International Air Transport Association

ICAO: International Civil Aviation Organization

IoT: Internet of Things

JTA: Job Task Analysis

MRO: Maintenance Repair and Overhaul

OJT: On-the-Job Training

P/N: Part Number

TATS: Task Analytic Training System (TATS)

TQM: Total Quality Managements

SMS: Safety Management System

SPSS: Statistical Package for the Social Sciences

1. INTRODUCTION

Management of procedures of aircraft maintenance is an essential process to run such programs efficiently and in a timely manner. Since the aviation industry is an international one, it has been standardized by international aviation organizations and agencies such as ICAO, IATA, EASA and FAA.

Generally, aircraft maintenance programs last between a couples of hours up to two months. In addition, they cost between some hundreds up to dozens of thousands of US Dollars. These facts make maintenance processes such a sophisticated one that needs to be carefully planned and uniquely managed. Not to mention that it must be conducted through highly trained staff who have to be up to these special missions.

Since the process is costly and complicated, there are a lot of issues and challenges that face this industry. Lack of training, poor management, tools and equipment misuse in addition to financial and organizational challenges are the most common problems of this business.

The purpose of this study is to investigate one of the most common problems that the aviation maintenance industry is facing that is the lack of efficiency in maintenance processes and the misuse of maintenance toolkits and hand tools. A thorough investigation of the aviation maintenance processes. A proposed code of conduct has been created to be applied in MRO organizations.

In the Literature Review section, maintenance programs, categories, scheduling and optimizing, issues and challenges in addition to latest technological applications used in aircraft maintenance are discussed. Later on, Methodology has been explained, results and discussion has been presented. Finally, future work has been mentioned.

2. LITERATURE REVIEW

In this section, a detailed literature review has been made to investigate any related papers to this topic. A focus on database that is published between 1986 and 2021 has been made to look into aircraft maintenance programs and categories.

This topic is a unique one and has been investigated by only a few researchers before.

2.1. Aviation Maintenance

2.1.1. Aircraft maintenance

2.1.1.1. Maintenance checks

Aircraft maintenance is a never-ending process. Every aircraft needs lots of maintenance during its operational life. From A to D, line to base, there are different categories of maintenance. These main factor in determining the maintenance program is the flight hours. Obviously, the amount of work and duration of maintenance depends on the type of aircraft.

Aircraft Maintenance Checks are as the followings (National Aviation Academy, 2020). See Table2.1.

Table 2.1. *Aircraft Maintenance Checks*

Type of Check	Time Interval	Duration	Work Man-Hours	Maintained Parts
A	3 Days	8 Hours	60	Airframe Power Plant Avionics System
B	6 Months	24 Hours	200	Main Systems Panels and Cowlings Fluids and Lubrications
C	3 Years	72 Hours	3000	Airframe Flight Controllers Internal Mechanisms
D	5 Years	20 *Days*	10000	Everything

A Check

It is made every 120-150 flight hours and includes a visual examination of the aircraft's airframe, power plant, and avionics systems. This check lasts for 8 hours and needs 60 man-hours.

B Check

This check is conducted every 750-800 flight hours and includes -in addition to the tasks of A check- some operational checks such as fluid checks and lubrications in addition to panels and cowlings control. It lasts for 24 hours and needs 200 man-hours.

C Check

Generally, this check is made every 3000 flight hours and consists of a detailed inspection of airframe, engines in addition to calibrate flight controls and test the major internal mechanism. This type of check lasts for 72 hours and needs 3000 man-hours.

D Check

This is the most complicated maintenance check. In this program, an aircraft is "stripped out". Most importantly, the aircraft structure is heavily inspected and every singly mechanism is calibrated. In addition, an aircraft gets a new interior design and a new paint. Because of its sophistications, this check lasts for 20 days and needs 10000 man-hours.

Pre-Flight checks happen every ground transit and involve some standard inspections of aircraft systems. Another type of checks are the Daily/Weekly checks where are required every 36 flight hours / 7 days respectively.

2.1.1.2. Line maintenance vs. base maintenance

In line maintenance, simpler activities are made. It can be conducted in every airport since no advanced tools are required. This includes checks transit, daily and weekly checks in addition to A and B ones.

Base maintenance, however, is the one that is conducted in larger, fully equipped hangars where C and D checks are made. This kind of maintenance cannot be made in every airport because of the required facilities. See table 2.2.

Table 2.2. *Types of Maintenance*

Type of Maintenance	Time Interval	Activities	Place of Maintenance
Line	Before Every Flight	Troubleshooting Defect rectification Component replacement	Aprons
Base	Scheduled Maintenance	Detection of Component Deterioration Removal of Defects Cabin Reconfiguration	Hangars

2.1.1.3. Maintenance trainings

Aviation industry is a top-expensive one. Every single part of an aircraft is an expensive one. Because of this, an On-the-Job Training is a requirement that every aviation technician must go under before getting on the real job. Over there, a trainee gets almost everything s/he needs to get to work. The more structures OJT is, the more reliability a maintenance organization can get through its technicians.

In her paper (Walter, 2000, p. 251-254), an eight-step-process model to optimize aviation maintenance OJT has been presented. The main goal of implementing this model in The Task Analytic Training System (TATS) is to develop a structures OJT.

Need Identification is the first step in this model. It is vital to the maintenance process because it is made by a documented-decision taken by management reflecting technical team's awareness of the maintenance need. Job Task Analysis (JTA) is the second step in this model. In this step, the design team conducts a task analysis that consists of breaking the job or task into small ones by determining the trainee's need to learn and their abilities to perform the job.

Project Planning is the third step of this model and it follows the job breakdown by designing a plan to keep the project's tasks on schedule. This is done based on the frequency, difficulty, and priority of the tasks. This is a critical step and the success/failure of a project largely depends on it. Writing Training Model is the fourth step and it is meant to aware trainees of their tasks through explaining to them what why, when, where and how they are expected to learn.

Training Implementation Plan is the fifth step of this model. It is intended for conducting workforce evaluations to determine who needs training and in which modules and by what dates, in addition to who will perform the training, and how the results of training will be measured. This step is so important because of its appointing characteristic. The sixth step of this model is Tryout, Evaluate, and Modify, in this step, written models have to be verified on-site at least twice, first by trainee with a trainer, and second, by one member of the approval team at least. Here, modules should be verified by using the same three-step job instruction training procedure as used during actual training.

Set-Up Maintenance Plan and Audit is the seventh step of this model. Here, manuals are distributed in work centers as resources guides that every person in the maintenance facility from line managers to operating staff has to have a version. Something unique about this is that such resources contain "Change Sheets" that are intended to make suggestions that technicians, operators, and managers think they should be added. The last step of this model is Start Training that as it is clear of its name, the step that actual job starts at. This is done through incorporating traditional job instruction training techniques by using a three-step training procedure. This procedure is composed of demonstrating the skill to the trainee by the trainer. Next, coaching the trainee through the elements of the task while the trainee performs them. Later on, the trainee does the task without coaching. This should end in both trainer and trainee discussing results afterwards.

2.1.1.4. Aircraft Maintenance tools, procedures, schedules

Maintenance tools

Aircraft maintenance tools are classified into two different categories. According to its guide, (EASA, 2018) has classified maintenance tools into “Standard Tooling” and “Task Specific Tooling”.

Standard tooling

They are the kind of tooling that is not being exclusively used in the aviation industry; is used in each industry and commercially available. There are many tools that can be classified in this category such as ladders, screw drivers, standard wrenches, circuit breakers, in addition to hydraulic valves and electrical circuits.

Task specific tooling

They are the type of tools that are specifically designed for a particular aircraft/engine/component etc. Each tool of this category has a unique part number -P/N- that specify this exact part. Generally, there are alternative parts -A/P- that can be used in case the original part is not available.

As an example, P/N C20449100 is a carbon brake assembly for the Airbus A321’s wheel. Again, this unique number is special for this type of wheels that are for specific type of aircrafts (locatory, 2021)

2.1.1.5. Maintenance technicians

Aircraft maintenance technicians are well trained and certified. In order to become an aircraft maintenance technician, one needs to get both knowledge and experience. This starts by getting theoretical knowledge and practical experience and ends by being an aircraft maintenance licensed technician.

Worldwide, there are two organizations that issue international aircraft maintenance certificates, they are EASA and FAA. Certificates issued by these organizations enable their holders to work in any maintenance facility anywhere in the world. Yet, some countries issue their own certificates that allow their holders to work in these countries.

To get EASA's License, one has to first get a basic theoretical knowledge. Then, s/he has to get a basic experience. Later on, one has to get an aircraft type rating through getting combined theoretical knowledge and practical experience and then get an On-the-job Training (OJT). Getting these steps done, one can apply and get his/her certificate (EASA, 2021).

Getting FAA's License is a little bit different from the getting EASA's one. To be an FAA-certified technician, one can get trained by a certified Aviation Maintenance Technician School (AMTS) or through directly getting an On-the-job Training OJT (FAA, 2021).

In Turkey, things are almost the same. However, since Turkey is not an EASA member nor have an FAA certified AMTS, its license holders can work in a very limited number of countries but not in the EU or US (SHGM, 2021) and (EASA, 2013).

2.1.1.6. Maintenance Toolkit

The aircraft maintenance toolkit can be considered as the core of the aviation maintenance process. There are different types and categories of maintenance toolkit but they do the same task; maintaining aircrafts. There are dozens of types of them of prices that can be as low as $500 and up to $10,000.

One of the most important things in dealing with such tools is that the tool shall be used in a reliable way which ensures the tool's safety and the task to be done precisely. In addition, a toolkit shall be itself maintained through periodical checks, inspection and calibration. Just like the aircraft they maintain, there are standards and regulations that toolkits shall meet.

One of the biggest threats that a hand tool can cause is its forgetfulness. This has been a challenge that faces the maintenance industry. On 3 November 2015, an Australian Police helicopter went under a regular maintenance where a technician forgot a spanner on the ground to be later on the rotor head area of the helicopter. By starting up the main engine, the tool was ejected by the rotor causing a significant damage to it sending it to maintenance again. Despite the fact that the maintenance staff had been trained on tool control, formal procedures had not been documented (Aerossurance, 2021).

Many suggestions have been presented to tackle such problems starting with classical foam shadow boards up to a fully automated tool kit that is run by a complex configurative system that can notify maintenance staff personnel about any dislocating, missing, out-of-calibration hand tools and sends automatic reports to maintenance managers (Snap-on, 2021). In this research, the different aspects of aircraft maintenance toolkit optimization have been investigated and a unique design aspects have been made.

2.1.1.7. Aircraft maintenance type-related cost

Obviously, maintenance costs significantly depend on the aircraft type. According to (Mofokeng, Mativenga and Marnewick, 2020, p. 469-471), wide body quadro-engined aircraft has more maintenance costs than twin-engined narrow body ones. The Airbus A340 has been found to have the highest cost maintenance among the Airbus family. On the other hand, the Boeing 747 has the highest cost among the Boeing one.

Shaukat et al., (2020, p. 3-6) Have presented a unique mathematical model that can be used to optimize line maintenance operations and allow some periodic block chain maintenance tasks to be performed through line maintenance ones. Based on this model, Line Maintenance Scheduling has been divided to two levels of planning: aggregate and operational. On the aggregate level, maintenance jobs should be assigned to available slots aiming to minimize deviation from due time. On the operational level, the exact time for each maintenance opportunity to be started is to be determined taking in consideration every airport's maintenance facilities and equipment.

2.1.1.8. Aircraft Maintenance through challenging times

Aircrafts go under maintenance programs either when they are operative (flying) or inoperative (on ground). Most major systems of aircrafts either mechanical, electronic, or hydraulic need to be periodically checked regardless of the aircraft situation; flying in the skies or stored in hangars.

Aviation industry might at any time face many challenging times that lead to the grounding of airlines' fleet. The biggest crisis that the aviation industry has faced in the recent years is the COVID-19 pandemic that the world is still affected by at the time of writing this thesis. In its guidance for managing aircraft airworthiness during and post pandemic, (IATA, 2020) has determined the conditions that aircraft should be storage according to. For such a pro-longed storage, electrical and avionics systems should be switched of and batteries to be disconnected. In addition, flight control surfaces should be kept clean and corrosion-free, protective coatings to be lubricated, and positing the controls to neutral positions. The same guidance recommends that engines and Auxiliary Power Units (APUs) have to be periodically operated, perform engine fuel systems conservations, and inlets/exhaust covers to be installed. Moreover, landing gears mechanism have to be lubricated, tires to be pressures and rotated to avoid surface flattening, and brake systems to be operated.

Long storage has a lot of disadvantages, interestingly, it has some advantages. In his article, (Batchelor, 2020) pointed out that such long on-ground periods enable airlines to perform “early” C and D checks that takes a lot of time to be performed. Doing this will not only make storage time as beneficial but also will keep aircraft airworthy and ready to fly any time flying restrictions are left.

Active Storage Program is another approach to deal with prolonged storage issue. Adrienne, Budd and Ison (2020, p. 3-5) has determined the most important factors that have to be taken in consideration while grounding an airline’s fleet. A storage location should be carefully chosen based on unique geographical and logistical considerations. In addition, maintenance staff should regularly perform some tasks even not to the full extent. Applying this program, it is supposed that an airline’s fleet will be ready to take to the skies once a decision is made with no more ground-time.

2.1.1.9. Aviation maintenance issues

As in every industry, aircraft maintenance has its own problems and challenges that occur because of different factors -mainly human-. In his research, (Samaranayake, 2006, p. 2246-2250) has summarized the different problems that aviation maintenance mechanics are facing. The main reason behind maintenance issues lies in the large number of maintenance projects, maintenance number of components, different maintenance levels, in addition to large number of configuration and huge amount of data.

The previous factors lead to maintenance planning and scheduling problems. These problems vary from lack of attain of spare parts required in addition to the fact that inventory levels are planned based on historic usage and moreover spending too much money on purchasing spare parts for urgent situations and ending in lack of details regarding unserviceable spare parts in inventory that can be services to use later on.

2.1.1.10. Safety Management System

Safety Management System (SMS) is defined as a technique that helps in preventing accidents, injuries, and minimizing other risks in a workplace through applying different principles, frameworks, and processes (Australian Government, 2021).

According to Gerede (2015, p. 109), "just culture" problems are the main challenge to the success of the SMS.

2.1.2. Human factors in aircraft maintenance

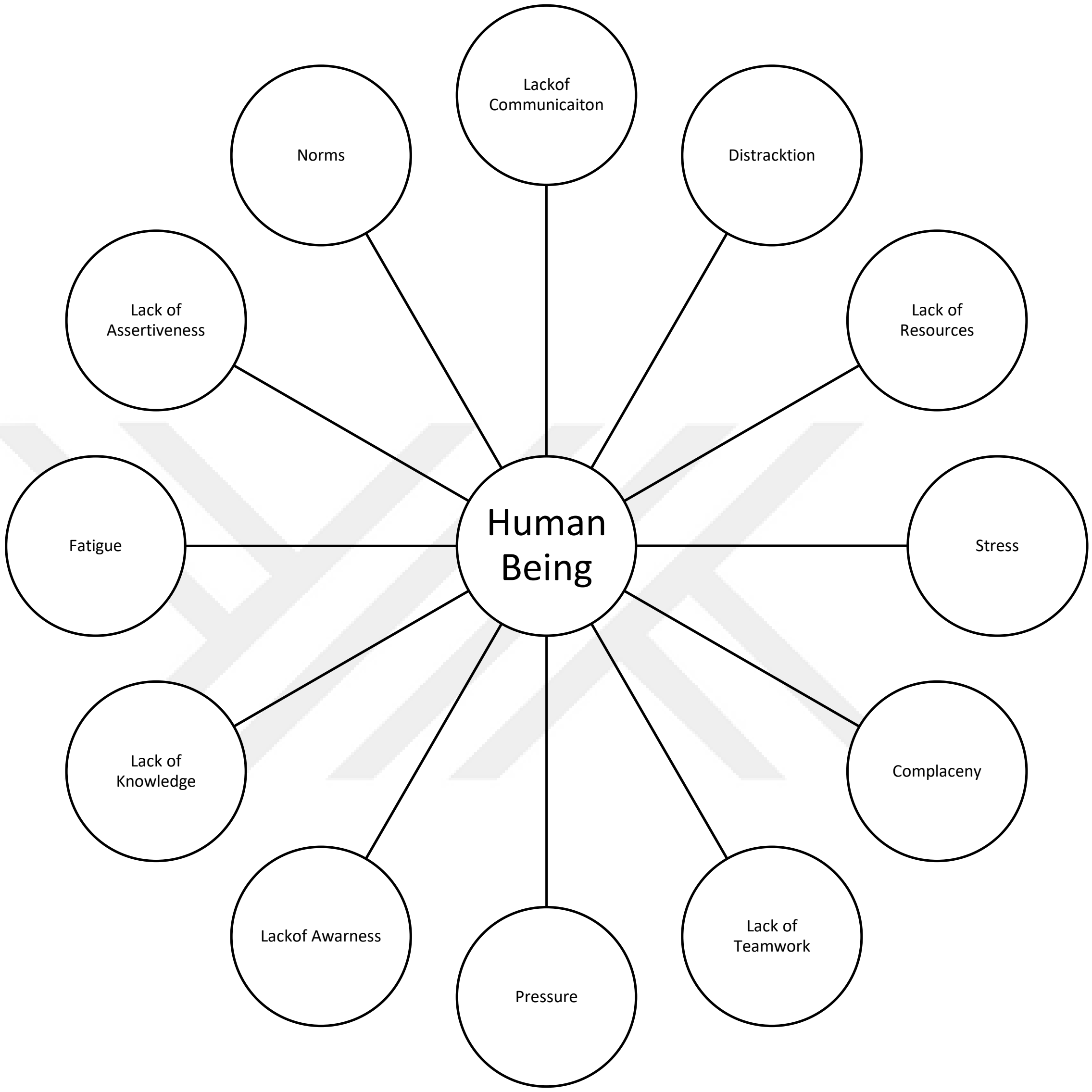
Human factors play a vital role in conducting safe and reliable maintenance. As aircraft systems are quite complicated and sensitive, this necessitates that maintenance staff get professional trainings before getting access to maintenance facilities.

SHELL Model is a key stone in understanding the effects that human factors have on the maintenance process. It investigates the relationship between the human factors and aviation systems. Applying this concept will clarify the relations between the aviation system environment and the human role in the aviation system.

In his paper, (Pickthall, 2014, p. 60-62) has brought up to light that the lack of maintenance on aircraft test tools in addition to insufficient onboard maintenance systems combined with the shortage of training on such equipment are the main reasons behind getting inaccurate diagnosis tasks that leads to No Fault Found incidents.

According to his model, (Usanmaz, 2011, p. 1684) has concluded that reducing maintenance failures -especially incorrect/incomplete installations-, AMP -Aircraft Maintenance Personnel- have to go through OJT -On-the-Job Training- before being certified to do maintenance. This will continually increase one's knowledge and skills and lead to reduce maintenance errors and failures.

Human factors play a vital role in conducting reliable and on-time maintenance programs since is all about the relationship between humans and aircraft systems.



Approximately, 80% of aircraft accidents are due to human errors such as pilots, air traffic controllers and mechanics (Boeing, 2007). In this section, a detailed investigation of human factors in aircraft maintenance will be made.

Skybrary (2021) has identified what is called "Dirty Zone", a concept that identifies twelve of the most common human error preconditions in the aviation industry. Each of these factors alone or together with other factors can lead to an incident or accident. The following figure illustrates these factors with human being to be centered at it. Figure 2.1.

Figure 2.1. *"Dirty Zone" Concept*

It is defined as a conceptual model that clarifies the scope of human factors in aviation and explains the relationship between them and the aviation systems and environments. It was first developed by Elwyn Edwards in 1972 and modified later on.

1.1.1.1. *SHEL model*

The SHEL Model considers the Human Being -herein referred to Liveware (L) - as the center of the model. As it is a center, so the other elements of the model shall have direct relations to it. S -stands for Software-; L -stands for Liveware-; H -stands for Hardware-; and E -stands for Environment-, all have a one-to-one relation with the core of the system; the human being (Edwards, 1972, p. 25-30). Figure 2.2.

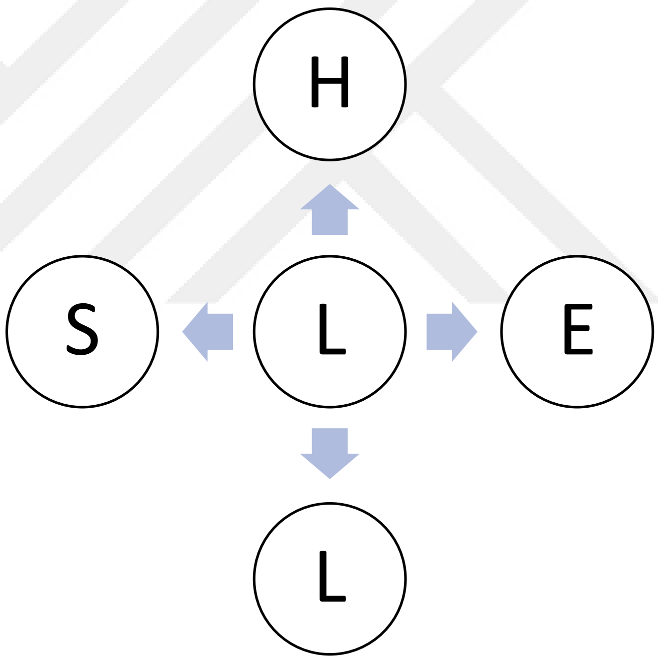


Figure 2.2. *SHELL Model*

S-L Relationship:

This interface illustrates the relationship between the human operator and the software support system in the workplace. It involves building a software that fits the general characteristics of the human users in a unique way.

The importance of this interface is to make a balance in the relationship between humans and technology to reach more reliable systems.

L-L Relationship:

This interface illustrates the relationship between any two human operators performing different tasks in the same work environment. In addition, it determines the interaction between the members of a group and between groups themselves.

The importance of this interface lies in be involved in contributing to the development of existed systems based on the recommendations made by operators.

E-L Relationship:

This interface illustrates the relationship between the human operator and work environment. It involves adapting both internal and external environments to match the human requirements.

The importance of this interface is to make work environment in distinct conditions to encourage operators to do their best.

H-L Relationship:

This interface illustrates the relationship between the machine -hardware- and the human operator. It involves matching the physical features of the machine with the general characteristics of the human users.

The importance of this interface lies in designing operating systems in an ergonomically way to get the tasks done in a unique way.

1.1.1.2. *SHEL model modified – SHELLO model*

In their research, (Chang and Wangb, 2010, p. 55) highlighted the importance of the relationship between the human being -Liveware- and Organization See Fig-2. This modified model takes in consideration determining risk factors for Aircraft Maintenance Technicians (AMTs) in each dimension of the SHELL Model. Figure 2.3.

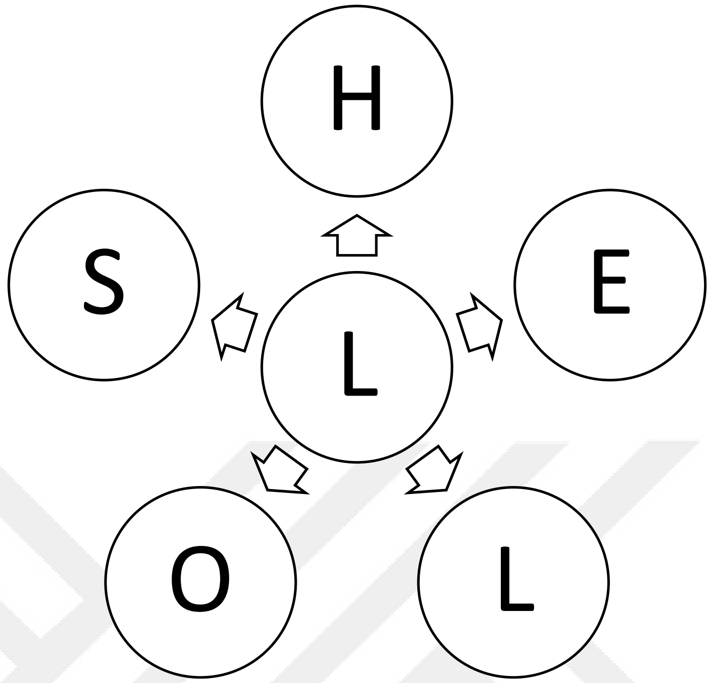


Figure 2.3. *SHELLO Model*

In this research, 9 risk factors have been determined as significant out of 77 preliminary and 46 primary risk factors. 3 out of these 9 risk factors have been found to be the highest in weight order of risk factors. They are Manpower/Man-Hour Planning, Safety Culture and Salary and Reward.

Applying this modified model will definitely help airlines and maintenance organizations to focus more on their managerial and organizational issues in order to improve their task performance.

2.1.2.3. Reason's "Swiss Cheese" model of human error

In 1990, James Reason has presented the concept of "Swiss Cheese" model of human factors for analyzing accidents (Shappell and Wiegmann, 2000, p. 2-3). According to this model, an accident happens as a result of consecutive errors that happen in a time manner. In this model, four levels of human failures consecutively happen in a way that each level influences the next one though being a latent failure till the active failure happens. Figure 2.4.

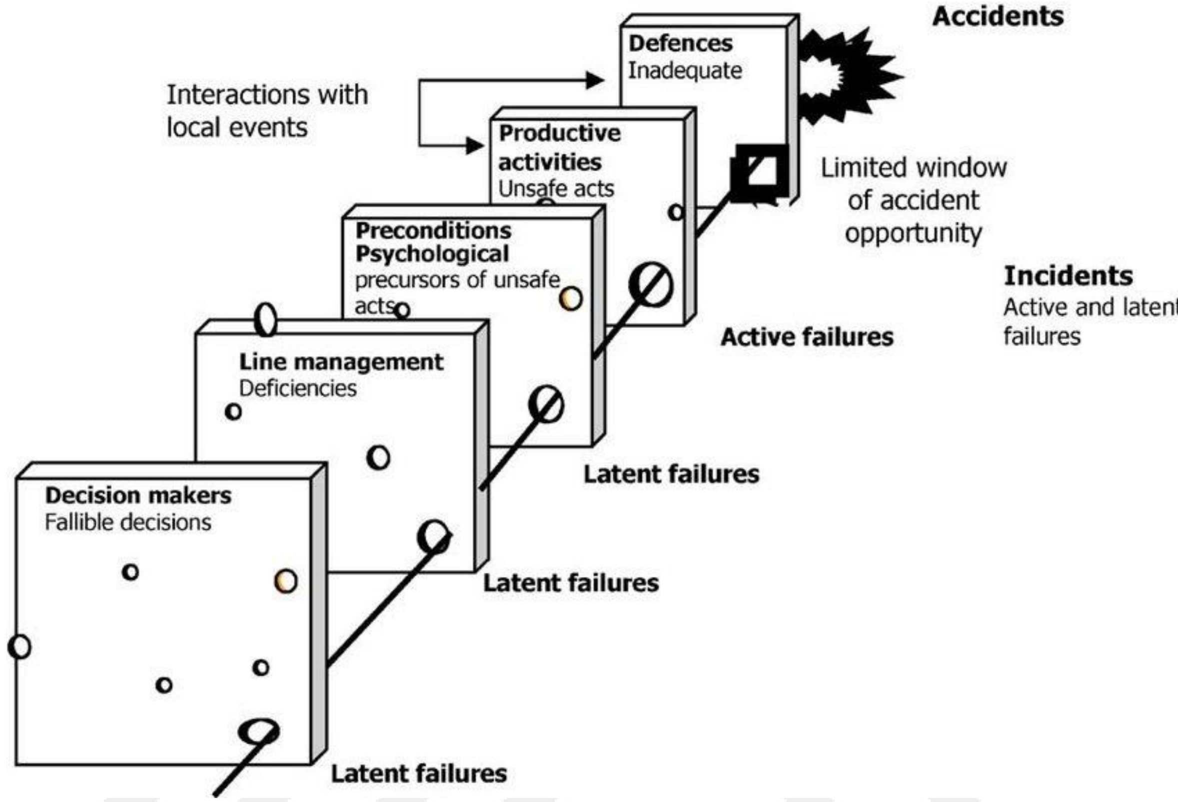


Figure 2.4. *Reason's "Swiss Cheese" Model of Human Error*

As a backwards in time before the accident, the first level depicts Unsafe Acts of Operators which ultimately led to the accident. This is commonly referred to in the aviation industry as aircrew/pilot error and this level is considered to be the one that most accident investigations have focused their efforts on and consequently, where most causal factors are uncovered.

The second level; Unsafe Supervision outlines an important issue in aviation maintenance that is the lack of rigid and reliable supervision. Such an issue results in a latent failure that will influence the maintenance process leading to an active accident.

The third level in this model is Preconditions for Unsafe Acts. This is an introductory stage to the complete failure were different conditions come together passing under irresponsible control that composes the most vulnerable environment for accident.

Finally, if any unsafe act takes place, then and as a logical result, the active accident will happen and an unavoidable failure will happen.

2.1.2.4.Human factors and the Industry 4.0

Today's ongoing digitalization of the traditional manufacturing processes is considered as the fourth industrial revolution; Industry 4.0 (Tay et el., 2018, p. 3-7). The far goal of it is to enable humans to communicate with machines rather than operating them.

Big Data, Cloud Computing, Augmented Reality in addition to the Internet of Things are the main characteristics of Industry 4.0. This will play a vital role in each industry it is applied at. Yet, there will always be a need for the human being since it is the core of any operational system.

Neumann et al., (2021, p. 3-5) Have presented a framework that can be implemented in developing operational systems that consider human factors in Industry 4.0. This framework aims to close the gap that is existed between the accelerating process automation and neglected human factors in Industry 4.0.

The first key concept of this model is that Industry 4.0 systems are sociotechnical system that means that human intervention is a principal and the attention to human factors should occur through design to get a reliable system and that is the second key concept of this model. The third one is that human-system interaction engages perceptual, cognitive, and motor systems that assures the mutual relation that should be maintained between the human and the machine.

People have psychosocial needs is the fourth key of this model. This necessitates the need to take in consideration the social needs of the workers into consideration when building the system. The fifth and the last key concept is that organizations tend to drift to unsafe states. This means that organizations should optimize the workers efforts within their limits in order to get their tasks done in a unique way.

2.1.3. Aircraft spare parts

2.1.3.1. Spare Parts Categorization

Basically, aircraft spare parts are classified into four different categories (Gu, Zhang and Li, 2015, p. 103-106). They are Rotables; Repairables; Expendables; Consumables. “Rotables” are the parts that are made of complex units and can normally be maintained unlimited number of times. An example of such category is an engine compressor fan that can always be repaired by replacing a damaged blade. “Repairables” are the parts that can be repaired limited times and have a possibility of having scrap. Any structural component can be categorized in this category. On the other hand, "Expendables" are the parts that cannot be repaired and will be definitely turned into scrap after removal. An aircraft landing gear is an example of such a category. Finally, "Consumables" are the parts that can only be used once. Chemicals are the best example of this category. See Table 2.3.

Table 2.3. *Spare Parts Categories and Characteristics*

Spare Part Category	Rotables	Repairables	Expendables	Consumables
Time of Service	Unlimited	Limited	Limited	Limited
Reparability	Yes	Yes	No	No
Number of Usages	Unlimited	Limited	Limited	Ones
Example	Aircraft Engine	Structures	Landing Gears	Chemicals

2.1.3.2. Spare Parts Supply

One of the biggest challenges that is witnessed in the aviation maintenance processes is to conduct the maintenance process not only in a unique and safe way but also on time. Spare Part Supply has been one of the most critical matters to be tackled by maintenance organizations. Simply, a supply shortage leads to a flight delay that causes an airline both a materialistic and ethical issues - financial and reputational costs.

"ESENTI" is a promising solution to the problem of the delay of delivering spare parts between Istanbul's 3 airports. The idea behind this project is to tackle the problem of crowded streets of this big city that causes delays in delivering spare parts leading to late maintenance aircraft delivery (Turkish Technic, 2021).

2.1.3.3. Spare Parts Inventory Management

An aviation spare parts inventory is one of the most important facilities that a maintenance organization must have. All different types of different categories of spare parts shall be available in such a facility. Managing such a big store necessitates different facilities and strategies to keep its contents deliverable anytime needed. Airlines and aviation maintenance organizations have always developed such tools such as the following:

Inventory Pooling

In their article, Kilpi and Vepsäläinen (2004, p. 140) have shown that a feasible pooling arrangement can decrease the inventory levels by up to 30%, something that can relive such companies and give them a chance to save such related costs and facilities. This idea was first applied in 1960s when the most European airlines had the similar fleets. This paved the way to create two maintenance consortiums called KSSU -an abbreviation of the four airlines contributing to it; KLM, SAS, Swissair and UTA- and Atlas, a consortium tha was made by Air France, Alitalia, Iberia and Lufthansa.

Nowadays, Lufthansa Technik and through following this strategy is a comapny that has over $2 Billion of spare parts available in 15 different places around the world ready to deliver anytime anywehre (Lufthansa Technik, 2021). Nowadays, this concept is being applied by many comapnies with Turkish Airlines to be one of the rising comapnies in this sector with a $500 Million of spare parts availabe in 4 different continents making it the world's first AIRBUS A320NEO/A321NEO pool component provider and the first MAX POOL provider soon. (Turkish Technic, 2021)

Using Internet of Things (IoT) in Inventory Management

As Industry 4.0 is becoming a dominant industry in lamost every sector, it has its own reflections on aircraft spare parts business. In his paper (Keivanpour and Kadi, 2019, p. 2345) casted the light on the advantages of using the Internet of Things (Iot) on spare parts inventory managemnt. Promisingly, Iot can relaibly facilitate inventory management operations such as forecasting ongoing demand, optimising system parameters and replenishment quantities.

Generally, four traditional generic practices have been used by airlines to manage the spare parts supply process (Kilpi, Töyli and Vepsäläinen, 2009, 367). They are In-House Sourcing, Ad-Hoc, Cooperative Pooling, and Commercial Pooling. Solo Strategy is another strategy that has been used by other some airlines. In each of these strategies, there are advantages and disadvantages. However, through using the Internet of Things (IoT) the application of all these different strategies can be feasible and Turnaround Time (TAT) -the biggest challenge that a maintenace company tackles- can be significantly reduced.

2.1.4. MRO industry

Maintenance Repair and Overhaul (MRO) Industry is one of the biggest industries on the transportation field. It is regulated by international civil aviation organizations such as FAA and EASA. Every year, different MRO Trade Shows are run in different places in the world. At such shows, professionals of different aviation business and markets come together in order to discuss the up-to-date MRO Industry and its future aspects.

2.1.4.1. MRO business forecast

MRO business is one of the biggest businesses in the field of transportation. The demand on air transport is expected to increase in a steady manner till 2038 with an expected total demand of new 39,200 passenger and cargo aircraft (Airbus, n.d.)This massive demand on new aircraft means that the demand on MRO will be increase, too. According to (Mazareanu, 2021), aviation maintenance business volume will reach up to $ 174 billion by year 2031 half of it will go only for engine maintenance.

2.1.4.2. MRO future

Despite that fact that the MRO industry is significantly dependent on human, this will definitely change in the near future towards a more machine-dependent industry. (SATAIR, 2018) Has made a vision about the future of the MRO industry. According to them, there are different emerging technologies which will change the MRO industry in a significant way. One of the most important technology is the implementation of robotics in the MRO industry. Robotics can be used to increase the efficiency of the metalwork in a considerably little time. In addition, drones can be used to do an aerial check of the aircraft both inside and outside maintenance hangars. This will save much time and effort that are spent in the traditional check time. Moreover, and most interestingly, Augmented Reality (AR) can be utilized for MRO trainings. This is a great technique to apply since it will lead to a great save on training materials, facilities and time.

Another interesting topic about aviation maintenance future is the implementation of Internet of Things (IoT) to control the aviation materials information flow (Lian, 2021, p. 288-291). Applying this through an aviation material pipeline system will reduce maintenance information lag, shortens waiting period, and improves turnover efficiency. Another important advantage of applying IoT is its ability to standardize aviation tool management that results in saving much time and effort searching for a needed tool.

2.1.4.3. Hangar of the future

Airbus, the world's leading company in aircraft manufacturing has started investing in its newest MRO project called "Hangar of the future" (Airbus, 2016) The project is aimed to tackle the rising demand in aviation maintenance especially in booming economic economies like Singapore's. Under this concept, classical human tasks such as locating equipment and information needed to prepare the task to automatically task-execution monitoring tool. In addition, Non-Destructive Testing -NDT- will be fully automated allowing maintenance personnel to concentrate of defect analysis instead of searching for data in maintenance logs. Moreover, and through the Internet of Things -IoT- integrated with Radio Frequency Identification (RFID) will be used to identify and track tools and parts leading to a great save in time and efforts. Finally, 3-D printing machines will be used to "build" needed parts in a relatively no time instead of manufacturing it through classical methods.

Boeing, the traditional rival of Airbus has introduced its own maintenance optimization concept (Boeing, 2021). Advancements of such a program includes "Airplane Health Maintenance" that is a real-time decision support tool that allows to make a better and faster data-driven maintenance decisions through converting its data into actionable information through benefiting from Boeing's deep engineering knowledge and in-service fleet experience. In addition, Boeing has introduced "Electronic Logbooks" as a replacement of paper logbooks in a way to improve both operational efficiency and reliability. Maintenance Turn Time is another unique advancement made by Boeing to minimize maintenance turn time through immediately troubleshooting defects. This technique allows users to share maintenance information in a secure time throughout maintenance and engineering organizations.

2.2. Aviation Management

2.2.1. Definition, features, objective, and functions

2.2.1.1.Definition

Management has been defined by many scholars depending on their own aspects of research. Thus, there is no single definition of management. However, they all deliver the same concept.

According to *Harold Koontz*, "*Management is an art of getting things done through and with the people in formally organized groups. It is an art of creating an environment in which people can perform and individuals can co-operate towards attainment of group goals*". However, and according to *F.W. Taylor*, "Management is an art of knowing what to do, when to do and see that it is done in the best and cheapest way" (Management Study Guide, 2021).

2.2.1.2.Features of management

The features of management are as the following (Juneja, Features of Management, 2020):

Management is Goal-Oriented - The success of any management activity is assessed by its achievement of the predetermined goals or objective.

Management integrates Human, Physical and Financial Resources - In an organization, human beings work with non-human resources like machines. Management integrates human efforts to those resources. It brings harmony among the human, physical and financial resources.

Management is Continuous - Management is an ongoing process. It involves continuous handling of problems and issues. It is concerned with identifying the problem and taking appropriate steps to solve it.

Management is all Pervasive - Management is required in all types of organizations whether it is political, social, cultural or business because it helps and directs various efforts towards a definite purpose.

Management is a Group Activity - Management is very much less concerned with individual's efforts. It is more concerned with groups. It involves the use of group effort to achieve predetermined goal of management of ABC & Co. is good refers to a group of persons managing the enterprise.

2.2.1.3.Objectives of management

The objectives of the management are as the following (Koçel, 2007, p. 112-117):

Getting Maximum Results with Minimum Efforts - The main objective of management is to secure maximum outputs with minimum efforts & resources.

Increasing the Efficiency of Factors of Production **-** Through proper utilization of various factors of production, their efficiency can be increased to a great extent which can be obtained by reducing spoilage, wastages and breakage of all kinds, this in turn leads to saving of time, effort and money which is essential for the growth & prosperity of the enterprise.

Maximum Prosperity for Employer & Employees **-** Management ensures smooth and coordinated functioning of the enterprise.

Human betterment & Social Justice - Management serves as a tool for the upliftment as well as betterment of the society. Through increased productivity & employment, management ensures better standards of living for the society. It provides justice through its uniform policies.

2.2.1.4.Functions of management

The most widely accepted functions of management are Planning, Organizing, Staffing, Directing and Controlling (Ülgen and Mirze, 2004, s. 25-26).

For theoretical purposes, it may be convenient to separate the function of management but practically these functions are overlapping in nature i.e. they are highly inseparable. Each function blends into the other & each affects the performance of others.

Planning

It is the basic function of management. It deals with chalking out a future course of action & deciding in advance the most appropriate course of actions for achievement of pre-determined goals. Planning is deciding in advance - what to do, when to do & how to do. It bridges the gap from where we are & where we want to be. Planning is necessary to ensure proper utilization of human & non-human resources. It is all pervasive, it is an intellectual activity and it also helps in avoiding confusion, uncertainties, risks, wastages etc.

Organizing

It is the process of bringing together physical, financial and human resources and developing productive relationship amongst them for achievement of organizational goals. To organize a business involves determining & providing human and non-human resources to the organizational structure.

Staffing

It is the function of manning the organization structure and keeping it manned. The main purpose of staffing is to put right man on right job. Managerial function of staffing involves manning the organization structure through proper and effective selection, appraisal & development of personnel to fill the roles designed on the structure.

Directing

It is that part of managerial function which actuates the organizational methods to work efficiently for achievement of organizational purposes. It is considered life-spark of the enterprise which sets it in motion the action of people because planning, organizing and staffing are the mere preparations for doing the work. Direction is that inert-personnel aspect of management which deals directly with influencing, guiding, supervising, motivating sub-ordinate for the achievement of organizational goals.

Controlling

It implies measurement of accomplishment against the standards and correction of deviation if any to ensure achievement of organizational goals. The purpose of controlling is to ensure that everything occurs in conformities with the standards. An efficient system of control helps to predict deviations before they actually occur.

2.2.2. Leadership, management, and discipline policy

2.2.2.1.Definition

Leadership is defined as "*The activity of leading a group of people or an organization or the ability to do this*". Another definition of leadership is "*The process of social influence, which maximizes the efforts of others, towards the achievement of a goal* (Kruse, 2013)".

2.2.2.2.Leadership and management

Even though leaders and managers have so many similarities regarding their responsibilities and actions, there are some main differences between them. The main difference between a leader and a manager is that a leader is responsible to lead -or influence-*people* to achieve a goal, however, a manager is responsible for leading things, tasks, or staff to reach a target (Güney, 2001, p. 28-29).

Leaders create visions, inspire others, build relationships, sometimes take risks, and coach their followers. However, managers create goals, do things in a systematic -sometimes bureaucratic ways-, maintain the statue-quo, and direct people.

2.2.2.3.Behavioral theories of leadership

Behavioral leadership is classified as such because it focuses on the study of specific behaviors of a leader. It is a unique predictor of the leader's influence and thus a determinant of his/her leadership success. Generally, there are two important behavioral studies (Gürel and Yılmaz, 2014, p. 60-62)

Ohio state university (1940s)

In this study, nine different behavioral leadership dimensions were under research. The study included many different sectors ranging from students with their supervisors, private companies, to military personnel. After compiling and analyzing the results, the study led to the conclusion that there were two groups of behaviors that were strongly correlated. These were defined as Initiating Structure (Task Oriented Leaders) and Consideration (People Oriented behavioral Leaders).

Task oriented leaders

The task-concerned leaders are focusing their behaviors on the organizational structure, the operating procedures (S.O.P.) and they like to keep control. Task-oriented leaders are still concern with their staff motivation; however, it is not their main concern. They will favor behaviors that are in line with *Initiating, Organizing, Clarifying, and Information Gathering*.

People oriented leaders

The people-oriented leaders are focusing their behaviors on ensuring that the inner needs of the people are satisfied. Thus, they will seek to motivate their staff through emphasizing the human relation. People oriented leaders still focus on the task and the results; they just achieve them through different means. Leaders with a people focus will have behaviors that are in line with *Encouraging, Observing, Listening, and Coaching and Monitoring*.

University of Michigan (1950s)

Lead by the famous organizational psychologist, Dr. Rensis Likert, the leadership studies at the University of Michigan identified three characteristics of effective leadership; two of which were previously observed in studies that had been conducted at Ohio State University. The study showed that task and relationship-oriented behaviors were not of major significance within the world of organizational psychology. However, it was the third observation that introduced a new concept, one of *Participative Leadership* -or *Democratic Leadership*-.

2.2.2.4.Discipline policy

Discipline policy is defined as a document that lays out the company's objectives and requirement for its employees. Generally, this document comes in different varieties depending on the needs of the company itself.

Discipline policy elements

The elements of any policy statement may vary from a company to another depending on many factors like cultural differences, ethical backgrounds, and even employee age ranges. However, all policies have the same basic elements. They are as the following (Koçel, 2007, p. 435-439)

Code of conduct

Employees should know the difference between expected and unacceptable behavior. Ideally, this should be in writing in a list of basic, general work rules or an employee handbook or other material provided to the employee.

Knowledge of disciplinary punishments

Employees should know the penalty they will be imposed for common offenses of the code of conduct. It begins with a verbal warning, written warning, final warning, and ends with termination.

Standardized disciplinary procedures

Employees should know that the steps and the sequence in which they occur in the disciplinary process will be the same for everyone. If a manager puts the steps in writing ahead of time, he should make sure that he follows the steps that he outlines for employees.

Appeal procedure

Employees should have the opportunity to voice their side of the story. While a full-blown appeal procedure may not be practical, a manager should at least give them a fair hearing before disciplinary measures are taken.

Reservation of rights

If a manager has a written policy, s/he should include a statement that the policy is to be used as guidance and that s/he reserves the right to modify the policy in any way should the circumstances require to do so.

Discipline and punishment

The basic and most important difference between discipline and punishment is that the discipline is a positive way to correct someone's mistake; however, the punishment is a negative way to do so. Yet, sometimes imposing punishments is necessary when "red lines" are crossed. A punishment should be imposed in a sequence way, beginning with a verbal warning, moving to a written one, making a meeting is recommended, but if it does not work, then termination should be done.

2.2.3. Contingency approach to management and leadership

2.2.3.1.Definition

Contingency Approach -also known as Situational Approach- is a theory of management that states that the most appropriate management style depends on the context of the situation, and thus adopting a fixed managerial style is insufficient for the long term (Koçel, 2007, p. 202).

The contingency theory has been presented by the Austrian psychologist *Fred Edward Fiedler* in his landmark article *"A Contingency Model of Leadership Management"* (Ülgen and Mirze, 2004, p. 44-45). Fiedler has studied leaders of variety of contexts, but he focused on the military ones. He categorized leaders into two different categories; task-motivated leaders, and relationship-motivated leaders.

2.2.3.2.The levels of the contingency approaches

There are five common components that contingency approaches have to have. They are as the following (Phimation, 2009):

Information

At the heart of a contingency plan is the ability to identify when a contingency exists. For some companies, the information is a metric or set of metrics. However, for others, it is a more instinctive feeling about the business.

Boundary conditions

Once a company has the set of information it is going to use to assess the situation, it then must decide under what conditions it will say a "contingency that must be addressed" exists. In other words, what is the "comfort zone" for the metrics, and where are the edges of that zone.

Levers

It is very important to identify the limits of any business that can be used to correct its paths. Determining the forms of the intervention that managers may take is significant, too. By recognizing these parameters, managers can take the most appropriate actions to keep their businesses developing.

Decision process

It is when a decision has to be made when a business goes through a critical situation. Some organizations might go for the present-decision making process that clarify the rules before the company goes into a contingency. Others have flexible comfortable situation that no decision is made before the contingency is faced.

Scenarios

This is for the preparation of the contingency plans for any potential issue that might happen. Making scenarios are one of the most important factors to apply the contingency approaches uniquely and effectively.

2.2.3.3.Major issues associated with use of the contingency approach

Since the contingency approach is intended to take an action to tackle a sudden situation and this action is based on kind of body of knowledge, certain key issues must be addressed. These keys insure the applicability and affectability of the approach, the main keys are as the following (Zeithaml, 2019, p. 49-56)

Selection and Measurement of Performance Variables

The selection and measurement of performance variables in contingency frameworks will influence the match between contexts and appropriate response variables. This will make the taken actions more effective when the approach is applied.

Identification and grouping of contingency factors

Identifying the contingency factors is significant to clarify the parameters that managers have to deal with. This is to frame the job that has to be done. In addition, grouping or categorizing the contingency factors is important to apply the most relevance business strategy. These variable groups could be environmental, industrial, competitive, behavioral …etc.

Independence of contingency factors

This is to clearly differentiate between the factors if the contingency approach where applicable. This is important to clarify the impact that the approach has done to each different parameter.

2.2.3.4.Number of levels in the contingency variables

The classical way to decide the outcome of any applied strategy is to use the dichotomies, i.e. yes/no, right/wrong, stable/not stable …etc. However, for the contingency approach, managers can evaluate the outcome in a more flexible way; i.e. successful, almost done, accepted …etc.

2.2.3.5.Deterministic view of the organizational context

In this level, the managerial view of context is not as fixed as it has to be in other managerial approaches. Here, a manager can accept the outcome as it is even if it did not match the desired outcome. This can be used when negative consequences might occur in case of being inclined to the traditional solutions.

2.2.4. Transformational leadership

2.2.4.1.Definition

Transformational Leadership is defined as a theory of leadership that focuses on influencing great change in attitudes, beliefs, and vision through the inspiration of the members of a group.

The term "transformational leadership" was first coined by the American sociologist James V. Downton in (1973). Then, it was first used by the American historian James MacGregor Burns in (1978) when he introduced it in his descriptive research on political leaders. According to Burns, the transformational approach creates significant change in the life of people and organizations. It redesigns perceptions and values, and changes expectations and aspirations of employees (Gürel and Yılmaz, 2014, p. 82-38)

2.2.4.2.The main elements of the transformation leadership

Koçel (2007, p. 462) has identified four different core elements of transformational leadership. They are: Idealized Influence; Inspirational Motivation; Intellectual Stimulation; and Individualized Consideration.

- *Idealized Influence (Charismatic Leadership)* – It is based on the leader's personality and charisma. Through, a leader can use his own example as a motivator to influence others.

- *Inspirational Motivation* - It is based on the leader's tangible optimism about achieving objectives. It requires a leader to support his subordinates by focusing on self-confidence.

- *Intellectual Stimulation* - This focuses on encouraging people to have innovative thinking personality and creative mentality. It stimulates them to have a determined personality.

- *Individualized Consideration* - Here, leader has to acknowledge the subordinates' individual contribution to the overall work. It also implies honoring the brightest minds.

2.2.4.3.Laissez-faire, transactional, and transformational leaderships

Laissez-Faire Leadership is the type of leadership where leaders are "hands-off", i.e. having no authority on their group members. This kind of leadership is taken when group members are required to make decisions -to be trained on it-. It has been noticed that it is the kind of leadership that has the lowest productivity levels (Bass and Riggio, 2006, p. 7-8)

The main difference between the transactional and transformational leadership is that the former one is taken when leaders want to keep their organizations' progress as it is, i.e. when they do not want to take risks towards achieving a higher market position or rank. However, the transformational leadership is the quite opposite where leaders are ready to do what is important to get their progress to higher levels.

2.2.4.4.The characteristics of a transformational leader

A transformational leader has to have the following characteristics (Güney, 2001, p. 297-298).

- *Self-management:* Transformational leaders typically don't need much direction from others. They are able to manage themselves well.

- *Ability to take the right risks:* It is a key characteristic of a transformational leader. Such a leader trusts his instinct and use his intelligence to make informed decisions.

- *Make difficult decisions:* Transformational leaders are those who take difficult decisions. They make them with a clear focus on the values, vision, and goals of their organizations.

- *Inspirational:* Transformational leaders have ability to motivate others to rise to occasion. They treat each employee as a valued individual and present what motivates him.

- *Adaptability:* Transformational leaders are ever willing to adapt to new situations, seek creative ways to respond to the dynamic business environment, and make the change.
- *Lead with vision:* Transformational leaders set a realistic and achievable vision for the organization. They then communicate the vision effectively to their followers, and also inspire a sense of commitment and purpose.

2.2.4.5.Transformational leadership effect on organizational performance

Boamah et al. (2018, p. 180-189) Have shown that the transformational leadership have an important role in enhancing the quality of the work environment. In addition, it is a paramount in improving job outcome. Moreover, it is a vital strategy for a total change if needed.

2.2.5. Strategic managements and leadership

The literature of organizations' structure contains two different important concepts that have many similarities but also have major differences. Strategic Management and Leadership have always dominated the modern classifications of organizations.

2.2.5.1.Strategic management definition

Strategic Management is defined as the approach of management where the main aim of an organization is to *-and for the long-term period-* achieve the organization's goals using its available resources in an efficient and sustainable way. In addition, it focuses on keeping the organization's good performance against its rivalries (Dogan, 2015, p. 1290).

2.2.5.2.Leadership definition

Leadership is defined as the activity of leading a group of people or an organization or the ability to do this in order to achieve a goal (Fener and Cevik, 2015, p. 696).

Strategic Management and Leadership are of the most important concepts to be applied to enable any organization to achieve its goals. In addition, a strategic management / leadership with an entrepreneurial vision can make an organization at its best position. Other factors have to be done to further keep developing an organization's process like the postmodernism approaches of management (Koçel, 2007, p. 283)

A pioneer organization is the one that has a strategic management approach, led by an entrepreneurial person and applying all the postmodern management schools' approaches.

2.2.5.3.Strategic management characteristics and process

Generally, strategic management have the following characteristics (Dogan, 2015, p. 1290)

Applicability: The main characteristic of a strategic management is that it is applicable for long-term periods where organizations can powerfully stand in the market.

Sustainability: Strategic management ensures the application of the future activities of an organization.

Purpose: The main purpose of strategic management is to increase the organization's profitability and efficiency through having a clear vision that is verified by a determined mission.

Analyticity: In short, the sources of organization, strengths and weaknesses, opportunities and dangers in the external environment are specified and analyzed with strategic management.

2.2.5.4.Strategic management phases

The main phases of the strategic management can be listed as the following (Ülgen, 2004, p. 36)

Long-period Planning: It is the first and most characteristic phase of strategic management. Having a long-period plan means that an organization is totally aware about its future position in the market.

Institutional Planning: It is the phase that implies the planning of the infrastructure of an organization, its managerial approach, and staffing action.

Strategic Planning: In this phase, many actions have to be done. It contains collecting and analyzing the data and information, presenting the possible strategies, and make a decision to choose a strategy. Some authors divide this phase into four different sub-phases; Conducting Planning Research -where analyses and assessments are conducted-; Defining Global Direction -where vision is defined-; Defining Strategic Direction -where "roadmap" is formulated- and Finalizing the Plan and Implementing it -where strategy is chosen- (Kotter, 2000, p. 5)

2.2.5.5.Strategic management and leadership

The difference between management and leadership lies into many aspects. Basically, management deals with “complexity” of organizations, however, leadership deals with “change” in organizations.

Management activities are meant to organize, control, and ensure the flow of work of an organization. However, leadership is meant to motivate, inspire, and change people in order to achieve an increased visionary people, thus organizations (Kotter, 2000, p. 8)

2.2.5.6.Strategic management, leadership, and entrepreneurship

Entrepreneurship is defined as the capacity and willingness to develop, organize, and manage a business venture along with any of its risks in order to make a change.

In today’s world, the organizational environments are becoming more complicated. In order to cope with rising challenges, organizations have to adapt the changes through pioneer steps, i.e. entrepreneurial ones.

The main focus of entrepreneurship and strategic management is on utilizing the opportunities and adapting to the change. Accordingly, *opportunities* are the ones to be of the most distinct connections between entrepreneurship and strategic management. Opportunities rank at the center of both entrepreneurship and strategic management (Kotter, 2000, p. 10)

2.2.5.7.Strategic management and leadership in modern approaches of management

There are many links between the modern approaches of management and the strategic management and leadership.

Contingency Approach is considered of the most important approaches of strategic management. A strategist presents a unique solution to any problem depending on its situational condition. Thus, a strategic manager prefers to create a “local” solution for a “local” problem rather than creating an overhaul one (Ülgen, 2004, p. 43-44)

It has been commonly accepted that leadership has a great role in the success of Total Quality Management. Since a leader is a qualified person who can influence others, he can exactly know what and when to do in order to lead a change (Fener and Cevik, 2015, p. 696)

2.2.6. Organizational management

2.2.6.1.Organizational culture

Definition

Organizational Culture (OC) is defined as the values and behaviors that contribute to the unique social and psychological environment of an organization. It involves all the distinctive spiritual, material, intellectual, and emotional features entailed by the employees' ways of thinking, feeling, and their personality manifested in their work processes (Rus and Rusu, 2015, p. 565).

Organizational culture characteristics

According to (Iljinsa, Skvarcianyb and Sarkanec, 2015, p. 946), an organizational culture involves many factors that are vital to its success. People Orientation; Team Orientation; Outcome Orientation, Innovation, and Empowerment are the most important factors to be considered. In addition, stability is considered as the most significant one to be focused on.

Types of organizational cultures

Park and Kim (2009, p. 22) have presented four types of organizational structure. They are: consensual culture, developmental culture, hierarchical culture, and rational culture.

Firstly, Consensual Culture focuses on concerns for people, and thus, values teamwork, participation, and loyalty. The Developmental Culture can be described as a dynamic, entrepreneurial, and creative place to work where people are encouraged to take risks and to focus on innovation, individual initiative, and freedom.

Rational Culture emphasizes results and getting the job done where people are competitive and goal-oriented. Finally, Hierarchical Culture is a formalized and structured place to work where procedures govern what people do.

In each organizational culture, a leader has specific characteristics and duties that are compatible with the nature of organization.

The relationship between organizational culture and leadership

In 1980, studies on organizational structure began to focus on the possible impact that an organizational culture might have on establishment. They have all showed that organizational structures have significant effects on performance, morale, job satisfaction, loyalty, and commitment (Warrick, 2017, p. 396).

One study had shown that a “healthy” organizational culture had almost 7 times average increase in sales against almost 1.5 time of the same parameter for a “non-healthy” one. Some companies have even doubled their stocks by 9 times!

Juneja (2018) and Warrick (2017, p. 399) have classified organization cultures into two groups; strong organization culture and weak organization culture. The former one implements that people enjoy working and take every assignment as a new learning and try to gain as much as they can. They accept their roles and responsibilities willingly. However, in the latter one, people do things out of compulsion. They just treat their organization as a mere source of earning money and never get attached to it.

Organizational culture and decision making

It has been found that there is a powerful link between the organizational culture and the process of decision making. Since making a decision in most times is considered as a “change process”, an organizational culture makes this process effective and reliable. This is because that in such an organizational structure, every single factor and component is considered in the analysis process and that what makes it very trustworthy (Ülgen and Mirze, 2004, p. 176-177).

Cultural intelligence

Cultural Intelligence (CI) – or Culture Quotient (CQ) - is defined as a measure of a person's capacity to function effectively in a multi-cultural environment. Generally, employers and organizations apply CQ as a way to foster tolerance and enhance cross-cultural interactions (Henderson, Stackman and Lindekilde, 2018, p. 954).

Today’s biggest and most successful companies all around the world are adapting this strategy as they ultimately believe in that their power lies in their diversity. These multi-national companies have to have a unique model of management and leadership that ensure their magnificent outcomes. Examples of such organizations can fill out many pages, however, Google, Apple, and Facebook are the most appropriate examples if such organizations.

In a study held by (Caputo, Ayoko and Ammo, 2018, p. 10-20), a sample of 403 employees completed self-report measures of all study variables were made. Many hypotheses and models were used to measure the effects that cultural intelligence might have on conflict management. The study shows that such a diversity of an organization will enhance its performance and overcome any rising problem through enhancing a certain conflict management style; avoiding problems, problem-solving techniques, power distance.

These three styles are basically related to the personnel's backgrounds, beliefs, and ideas. Such a diversity will shorten the distances between "conflicting parties" and leads to a sustainable peaceful solution.

Organizational Structure has always been a strategy that been followed by different organizations. It has many characteristics that have to be considered by managers or leaders to ensure their organizations' success. Cultural Intelligence is another important concept that is applied by bigger international organizations to further improve their outcomes and goes up to globalism.

2.2.6.2.*Organizational commitment*

Organizational Commitment (OC) is defined as the individual's psychological attachment to the organization. It is one the most widely researched topics in the field of organizational behavior. The definition of organizational commitment has evolved through time taking in consideration the different factors and variables that both organizations and employees experience (Reichers, 1985, p. 467).

Porter et al., (1974, p. 604) have identified commitment as the strength of identification and involvement that an individual has towards an organization. They have characterized such commitment by three factors: a belief in and acceptance of an organization's goals and values, willingness to do efforts on behalf of the organization, and a solid desire to keep an organizational membership.

In his article (Hanaysha, 2016, p. 294-295), the researcher highlighted the effects that employee engagement, work environment and organizational learning might have on organizational commitment. According to them, all these three factors have a significant impact on raising employee's organizational commitment. In addition, organizational learning was found to be considered as the most important process to be adapted by managements to lead their organizations to advanced competitive places and increased performance.

Organizational commitment dimensions

Meyer Allen (1991, p. 61-89) Have presented a determined three-component conceptualization of organizational commitment. They have investigated commitment as a psychological state and defined its components -dimensions- as affective; continuance; and obligation. They have considered each component to develop as a function of different antecedents to have many different implications for on-the-job behavior.

Organizational commitment and temporary organizations

Today's business markets are characterized by an ongoing accelerating development process. This change has reflected on the business structure leading to some unique changes that most likely will last forever. Temporary Organizations are one direct result of it and it is becoming more and more adapted.

In their research, Spanutha and Waldb (2017, p. 135-136) have spot the light on the effects that a temporary organization might have on organizational commitment. To a large content, temporary organizations have the same significant effects that permanent organization have on organization commitment such as job complexity, type of the organization, and work-life-conflict. The only factor that has no significant effect on temporary organizational commitment is career opportunities. Taking these effects into consideration will enhance the temporary organizational commitment to get its vision achieved.

Spanutha and Wald (2017, p. 135-136) Have also investigated the antecedents of organizational commitment in the context of temporary organizations. They have found that Work Autonomy, Job Complexity, and Trainings have a significant and positive effect on TOCs while Career Opportunities, however, does not. In addition, they have found that there is a positive relationship between job complexity and organizational commitment in temporary organizations. In another words, the more complex the task is the higher commitment staff have shown. Another important and interesting factor result is that the type TO itself has a significant impact on TOC. This is an important factor to be considered in investigating such issues related to organizational commitment. They concluded that career opportunities have no significant effect on TOC and this is because of the nature of promotion in such organizations where promotion is made by superior line manager rather than respective temporary organization leader.

Organizational commitment and ambition

In their article, (Hirschi and Spurk, 2021, p. 11-12) have investigated the effect that ambition might have on organizational commitment. As expected, ambition has been found to have a significant impact on the workplace outcome. It leads to a higher affective organizational commitment further on any striving achievement especially when unique career opportunities are perceived. However, ambition itself poses some risks to the organizational commitment because of the high turnover intention found at ambitious employees. So, this can be considered as a dilemma that managements of organizations have to carefully tackle.

Organizational commitment and career management

In every organization, there are many factors that lead to some issues like job dissatisfaction, turnover intention, and burnout to come. This can be a direct result to a poor management, bad work environment, lack of support and supportive networking … etc. To test this out, (Soares, M. and Mosquera, P., 2021, p. 547-559) have investigated these factors in their research. They concluded that both organizational support and management's / colleagues' one in addition to career guidance can be positive to the individuals but not for the organization since it might lead to a lesser affective commitment and increasing the intentions of turnover and depersonalization. They have also entailed implications for the HR managers through by making career management practices targeted to a specific outcome that an organization aim to achieve and paying special attention to networking considering the detrimental effect potentially on personnel depersonalization, commitment and retention.

2.2.6.3.*Organizational citizenship behavior*

This terminology represents the voluntary commitment of a person towards his/her organization considering tasks that are not of his/her contractual ones. Much attention has been made to it since 1970s when many changes happened to organizational structures and work environment.

In their research, (Pradhan, Jena and Kumari, 2016, p. 10-12) investigated the role of organizational commitment -as a meditator- to study the effects of Work-Life Balance (WLB) have on Organizational Citizenship Behavior (OCB). Generally, Altruism, Coconsciousness, Courtesy, Civic Virtue, and Sportsmanship were found to be significantly extant in organizations that focus on enhancing Social needs, Personal Needs, Time Management, Teamwork, and Compensation and Benefits.

Having attained these requirements, employees will start to experience a "psychological contract" that will enhance their loyalties and lead to better performance levels.

In their research, (Devece, Palacios-Marqués and Alguacil, 2016, p. 2-4) have spot the light on the organizational commitment effects on organizational citizenship behavioral in a high-unemployment environment. According to their results. A high-unemployment environment has a clear effect on organizational commitment especially on its continuance dimension. On the one hand, it can affect continuance dimension at two different levels, it will change the employee's perception of how will his/her survive jobs based on the organization's strategies because of the scarce opportunities available outside the organization. On the second hand, a plenty-of-opportunities organization will let its employees to reflect motivation derived from one's own interest.

2.2.6.4.*Organizational changes on aviation safety*

Generally, safety indicators can be categorized into two different categories; reactive -outcome-based indicators- and proactive -activity indicators-. The aviation industry has considered only reactive indicators as a safety measure. Yet, these measures cannot provide the complete picture of the safety level.

In their research, (Herreraa et al., 2009, 1158-1162) have spotted the light on the impacts that organizational changes might have on aviation safety. They have found that major changes have significant impacts on safety. Merging of companies, splitting companies' technical and operative parts, in addition to the reduction and movement of personnel in production lines are considered among the most changes that have such an impact on aviation safety.

2.2.7. New Schools of Management

2.2.7.1. Lean management

Lean Management was developed in the 1990s at the Toyota Production System and was successfully applied in both Japan and The West. Basically, this concept implies that a determined value of a product should be made by the available resources and that any expenditure of them is a wasteful and thus should be curtailed (Kiran, 2016, p. 225). Figure 2.5.

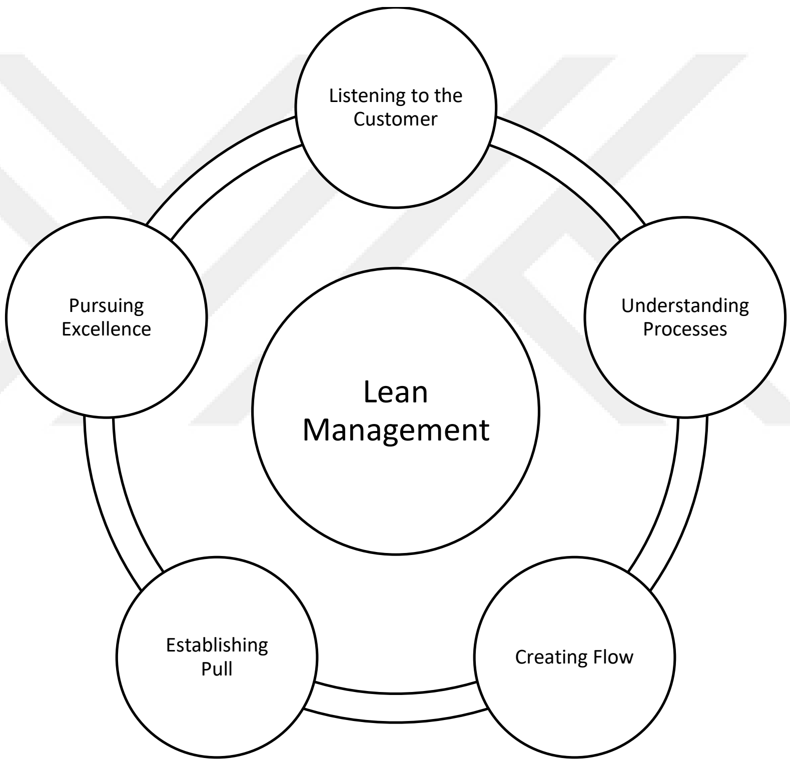


Figure 2.5. *Lean Management Factors*

2.2.7.2. Total quality management

In his book, (Kiran, 2016, p. 248) has defined Total Quality Management (TQM) as an integrated system of principles, methods, and best practices in addition to organization-wide efforts to make a permanent climate in which an organization to continuously improve its ability to deliver high-quality products. Figure 2.6.

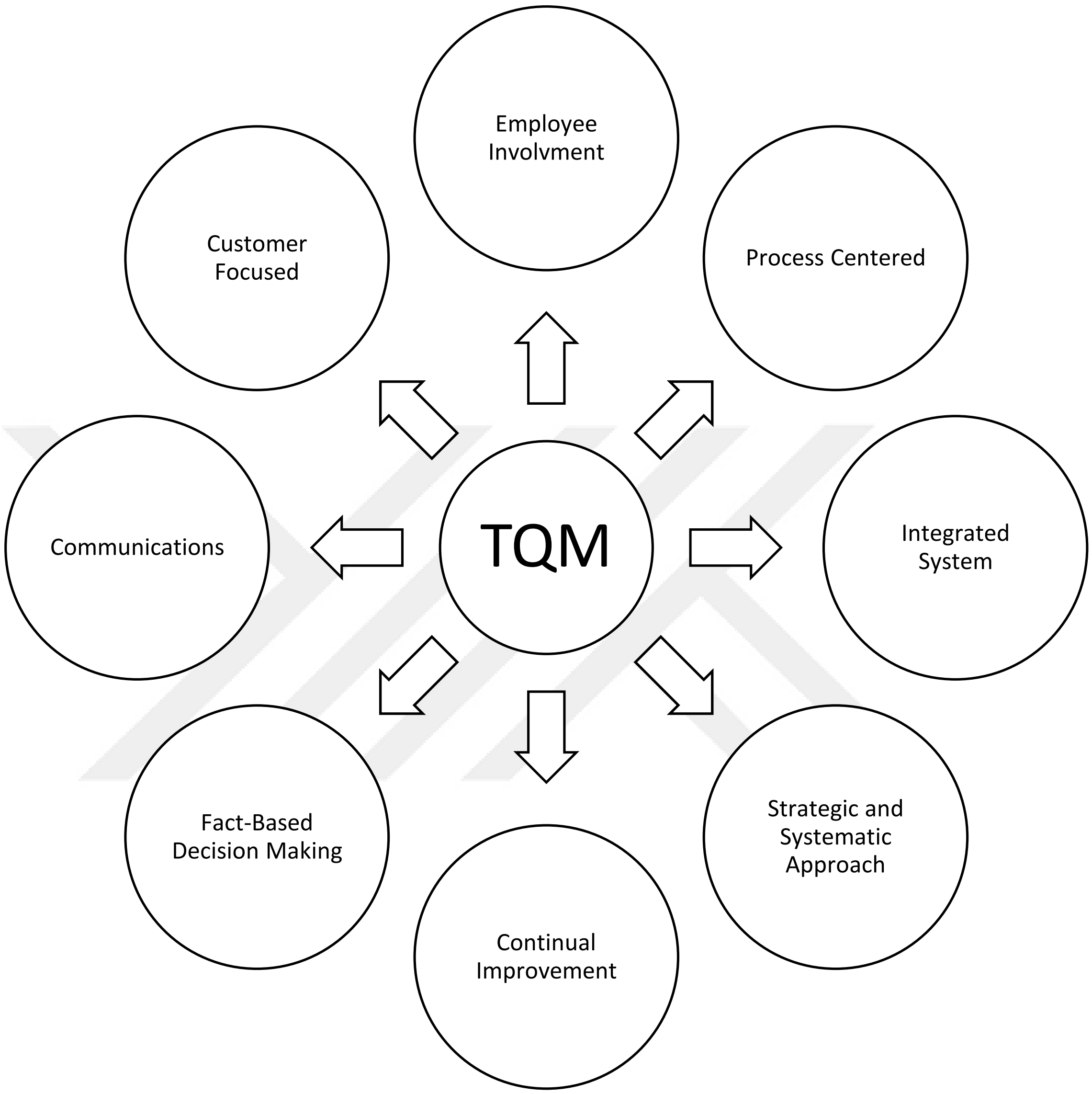


Figure 2.6. *Total Quality Management Factors*

2.2.7.3. Six sigma

The concept of Six Sigma has been presented by a team of engineers at Motorola led by Bill Smith back in 1980s. It was a culmination of previous research made by mathematicians and engineers starting in 1920s (Kiran, 2016, p. 318).

Six Sigma can be defined as a management system that is composed of different techniques to compose a measurement of process improvement. In addition, it can be considered as a strategy that is followed to achieve an organization's vision.

The techniques implemented in this concept are Define, Measure, Analyze, Improve and Control. Figure 2.7.

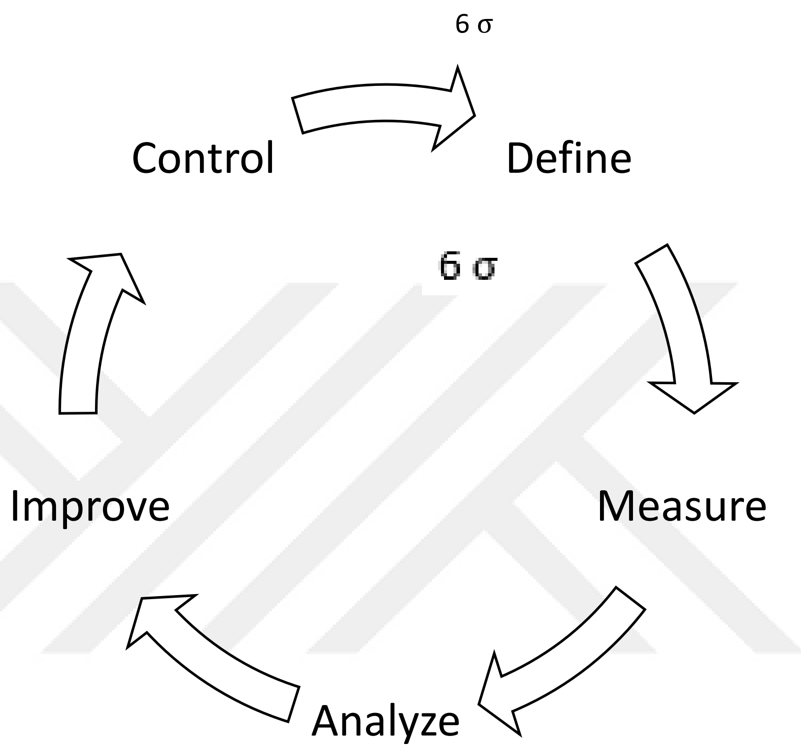


Figure 2.7. *Six Sigma Concept*

2.2.7.4. Kaizen

This word comes from Japanese and it is composed of two syllables; "改 – Kai" which means "Change" and "善 – Zen" which means "Good" thus it means "Change for the Good". It emphasizes the continuous improvements in the production processes.

This principal has been prevailing in recent industrial and production schools. Its uniqueness is all about the continuous development in production processes through "equipping" personnel with required skills and trainings in addition to "optimizing" work environment. This strategy is based on the following consequences: identify problems that is to have an understating of the issue then analyzing current processes that are run to tackle such issues. After examining the problem and understating it a solutions-creating step takes place followed by testing such solutions to verify them. Measuring and analyzing results is the fifth step in this scheme and it is followed by standardizing the solution to get a reliable solution to an existing problem. Figure 2.8.

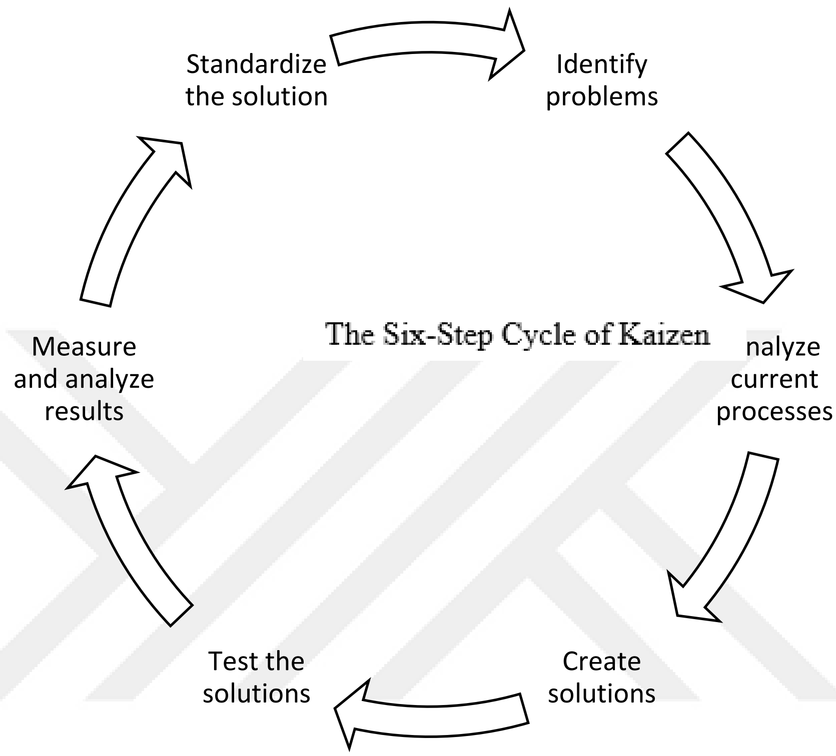


Figure 2.8. *Six-Step Cycle of Kaizen*

2.2.7.5. PDCA

PDCA is an iterative design and management method used in businesses for the continuous improvement and control of processes and products. It is a scheme of consequence steps "Plan"; "Do"; "Check" and "Act" that leads to a sustainable production process (Prashar, 2017, p. 277-293). Figure 2.9.

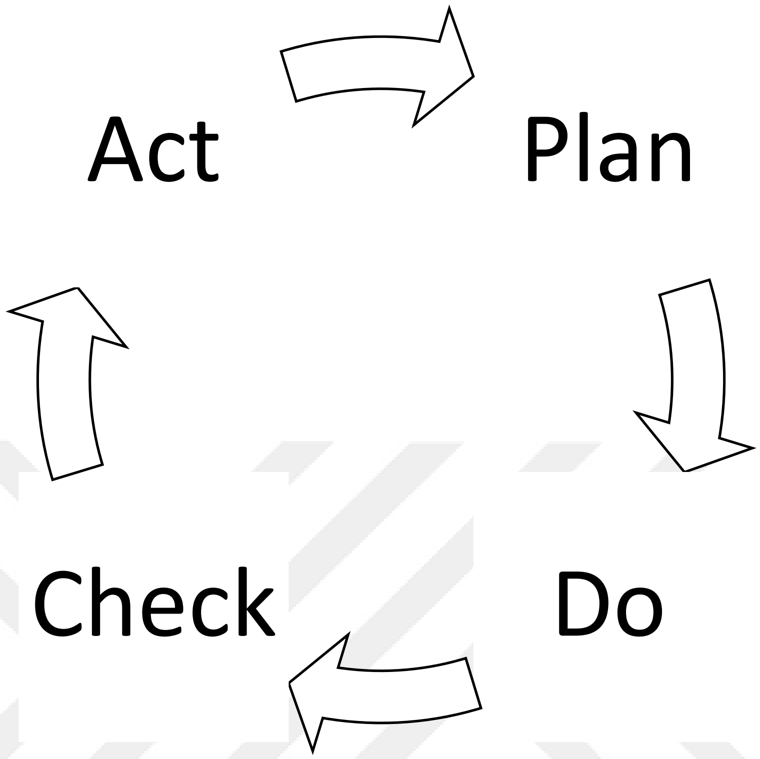


Figure 2.9. *PDCA Concept*

3. METHODOLOGY

In this section, the conducted research has been explained in details.

3.1. Research Model

A qualitative research has been conducted to find answers to the presented issues related to aircraft maintenance. A detailed 5-category questionnaire has been presented to people who are involved in aircraft maintenance of different positions with different work experience who are on duty at different airlines or even out of work.

The main goal of this research is to find out the main challenges that aircraft maintenance staff are facing in today's industry. In this concept, questions regarding the participants' demographic data, work environment conditions, Maintenance Bag and Hand Tools orientation, usage and sources of damage orientation, in addition to maintenance safety culture orientation were presented.

3.2. Research Area and Participants

Methodology: A survey using Google Docs has been made that its participants were EASA-66 Part Exam takers at Anadolu University.

The main purpose of making this research is to optimize the aviation maintenance process the usage of hand tools, develop maintenance environment and investigate the effects that human factors have on maintenance process.

The survey made by this analytical research was made on 15th-Jan-2020. Later on, in March 2021, the literature review was finished. All different analysis, results discussion and recommendation for future research was completed in May 2021.

A Google Docs has been used to run the survey. In addition, some questions have been adapted from "Workplace Safety Climate Survey" (Prairie Research Associates, 2015). Moreover, a Likert scale has been used to measure the collected data.

The survey has been taken by 215 of EASA Part66 Exam takers. They of different employment status as employed, unemployed, and students. 138 of surveyed persons were actually employed, however, 27 were not at the time of research but of a considerable experience. Those together -165- were out of 4547 aviation maintenance technicians in Turkey (Turkish Civil Aviation Council, 2019).

3.3. Data Management

In this section, the followed methodology doing this research has been discussed. The research topic, role of researcher, credibility of the research, different points taking in consideration during the research, and interpretation of the results have all been presented.

To analyze data, an SPSS V.25 Software has been used. The data was collected through a survey composed of 33 questions and an area for suggestions and recommendation. The survey was taken by participants in the SHY66 Exam that took place on 15-Jan-2020.

3.4. Researcher's Role

Aviation maintenance has been always under research. The main reason for this is to reach a point when maintenance is uniquely optimized in a time manner. To tackle today's aviation maintenance issues in Turkey, this research has been made. The researcher has been interested in this field since his undergraduate level. A software to manage the effects of aircraft absenteeism due to maintenance -whether scheduled or emergent- on flights schedule has been built by him as a graduation project. In addition, the researcher has covered bunch of master's degree subjects related to the field of aviation management. In addition, an academic paper tackling the maintenance optimization has been written as a participation into the 5th Entrepreneurial & Communication Social Science Congress held between 29-30 June 2020 held in Gostivar – North Macedonia -participated virtually online due to travelling restrictions because of COVID-19 pandemic- with a paper under the title " Safety Culture: Maintenance Box and Hand Tools Usage Tendency"

3.5. Persuasiveness

In this research, a quantitative research has been made. Validity and Reliability of data have been made sure to be investigated against collected data. To make sure of this, every participant's details were hidden given them the highest level of privacy so they can reassuringly answer to the survey's questions. In addition, all collected data were saved by the researcher and the supervisor to ensure its safety.

During the research, all data have been analyzed and reported to the supervisor in a periodic way. In addition, all analysis and reports have been checked by professional people making sure they are in a consistency with the research. Moreover, findings, results and explanations made as a result of the research were also examined by these experts and all data and documents collected during the research were kept

3.6. Ethics

The researcher acted in accordance with ethical principles during this study process and carried out the following studies:

- With the snowball sampling method used within the scope of the research, different participant suggestions were received from the participants, who were thought to contribute to the study.

- It was stated that participation in the study was voluntary and verbal and written consent was obtained from the participants that they participated in the study in line with their own wishes and desires.

- All participants contributing to the research were informed about the research objective, subject, problem and methodology, and the survey was completed within this scope.

• Participants; the data collected within the scope of the research will be used only for scientific purposes. Participants were informed that data will not be used outside the purpose of the research or in another research and they will not be shared with others without their (written) permission, and that they can withdraw from the study at any stage if they wish.

• It has been clearly stated that the participants have the right to examine the collected data upon their request and that the collected data will be protected by data retention method in accordance with the law on the retention of personal information and will be archived or destroyed after the research.

• In the research report, by paying attention to the confidentiality of the participants, numbers were used instead of the names of the participants.

3.7. Data Analysis and Interpretation

Generally, the respondents were varied in their age, educational background, years of experience, positions held, and companies working at.

93.5 % of the participants were male which means a significant dominance of this gender over the aviation maintenance industry. 61.9% of the respondents hold a B1.1 Maintenance Category in addition to 18.6% hold a B2 Maintenance Category. Simply, this high percentage means that there is a larger focus on mechanical systems maintenance for turbine-engined aircraft. This can simply reflect the high demand on this maintenance category in the aviation market.

There is an interesting percentage ~18%- of the respondents that they were graduated from non-aviation educational schools. This might be explained by knowing that the high demand on this industry especially in booming aviation markets like Turkey in addition to the high salaries expected from such companies as will be referred to later on.

Another noted ratio is that ~23% of the participants were still students. This can be justified by knowing that the aircraft maintenance companies in Turkey do not hire graduate students from Turkish Universities unless they pass such recognized examinations. The other ~77% were wither currently working or out of work and in both cases, they were taking the exams to wither get a promotion or increase their employability.

About 50% of the participants were working at Company A, the official affiliate aircraft maintenance company of “Company A” is the conventional carrier of Turkey. It is easily understandable that all maintenance staff prefer to work at this company since it is the best one in terms of beneficiaries that are presented to its staff.

Almost two thirds of the respondents were of new work experience. This means that they are trying to explore the different opportunities in this field. However, there were 7% of the participants who were of +20 years of experience, yet they were trying to get new adventures!

Considering the number of times that exam takers have been taking it, almost a quarter of them were taking it for the first time. Surprisingly, the other 75% of them were taking it for more than once! This means that passing the exam is not an easy task. This can be understood when we know that 85% of these people were having no license.

The salary that these staff are getting is almost the most "equally" distributed ration. Almost 50% of the staff were getting between $500 up to $1000 per month -depending on the official currency at the time of writing this thesis-. Only 25% were getting higher than this salary but it was for those who have more than 7 years of experience.

Considering the environmental physical conditions and despite the majority of respondents who expresses their satisfaction about it, there is a considerable percentage who showed a total/partial dissatisfaction or neither satisfaction not dissatisfaction about it. A similar percentage has been found about the availability and accessibility that maintenance staff have. These two ratios -even for small percentages- should be seriously taken in consideration while managing a maintenance facility since it is vital to avoid any human error in maintenance processes since they are of a high percentage of aviation accidents

Questions Considering Maintenance Box and Hand Tools Design

Since a main goal of this research is about to find out the main reasons that lie in the "misuse" of maintenance equipment, a significant focus about the design of maintenance box and hand tools has been made. The results reflect some interesting facts about the maintenance processes at such facilities.

One of the most interesting results got was the high percentage of participants who expressed that maintenance tools are used in actions they were not designed for! This is a serious risk that must be overcome to prevent any maintenance mistake at any process.

Almost 40% of respondents showed that the maintenance toolboxes are not designed in a way that make them easy to move. This is a real problem that affect a maintenance worker's performance. On the hand, a wide majority of participants expressed that the maintenance toolboxes are designed o a way that the hand tools can be found easily.

About 45% of participants see that the weight of the maintenance boxes is so high because of the existence of many unnecessary tools in it. This cast a shadow on the necessity of reviewing the need for maintenance tools to be existed in the maintenance boxes.

One fifth of the respondents see that the maintenance kits are designed in accordance to the maintenance documents as if they were created by highly-skilled people like maintenance managers or chiefs. Thus, they -participants- see that there are no tools missing in maintenance boxes.

Another important percentage is that almost 40% of respondents expresses that they generally see some broken tools in received maintenance boxes. Damage to such tools is seen as a normal thing during maintenance process and this might explain the high percentage of finding damaged tools in such processes. A small percentage of these people see that if they report about damaged tools in their boxes. This is a real problem that will lead to a further one if necessary actions were not taken. However, and with a variety of percentages, respondents see that without notifying management about damaged or worn-out tools, they can't be renewed. This is contracted by knowing that participants see that there are regular checks on the maintenance tools run by their companies.

An interesting percentage of respondents -more than a half- see that their colleagues are not cooperative when it comes to ask to "borrow" some hand tools when in need. This can be considered as a good indicator of organizational commitment knowing that any missing tools should be reported to the management not to be asked to be "compensated" by other team members.

Another weird thing to be notices is that almost a half of the participants expressed that they haven't got a regular training of safe use of maintenance tools. This is a real issue that must be tackled before things get worse.

About 70% of the respondents expressed that regular activities are run to keep guiding them on the most updates regarding maintenance activities. This is a good indicator that reflects maintenance companies' commitment to keep their staff up to date regarding maintenance facilities, tools, and issues.

The last question's answer explained it all when the super majority of the participants expressed their belief that it will take a long time till maintenance safety culture change. This is a real challenge that aviation maintenance industry has to rise to.

4. RESULTS AND DISCUSSIONS

In this section, different hypotheses have been made to investigate the relationships between different factors involved in aviation maintenance.

4.1. Gender Effects on Tool Box Design

4.1.1. Tool box weight

Hypothesis-1: Gender (P-1) has an effect on the design that considers the easiness of carrying a maintenance toolbox (P-15).

To investigate whether "Gender" has an effect on the staff's abilities to easily carry a maintenance toolbox or not, the following analysis has been made excluding Students.

Table 4.1. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the gender of the maintenance staff and the weight of the tool box*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-1 * P-15	165	100.0%	0	0.0%	165	100.0%

Crosstabulation

Count

		P15					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-1	Man	13	14	38	37	53	155
	Women	1	1	5	1	2	10
Total		14	15	43	38	55	165

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.732[a]	4	.443
Likelihood Ratio	3.552	4	.470
Linear-by-Linear Association	1.268	1	.260
N of Valid Cases	165		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is .85.

This question has been asked because of the common thought that due to the physiologically nature of men and women, it is supposed that carrying a maintenance tool box can be an issue to women. According to the results of the analysis and Chi Square Test, there is no relationship between the gender of maintenance staff and the easiness of carrying maintenance toolboxes

4.1.2. Tool box unnecessary tools

Hypothesis2: Gender (P-1) has an effect on maintenance staff's opinion about the heaviness of the maintenance toolbox considering containing unimportant tools or not (P-18).

To investigate whether "Gender" has an effect on the staff's opinion whether maintenance toolbox's weight is related to containing unimportant tools or not. The following analysis has been made excluding Students.

Table 4.2. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the gender of the maintenance staff and the opinion that the tool box usually has unnecessary tools*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-1 * P-18	165	100.0%	0	0.0%	165	100.0%

Crosstabulation

Count

		P-18					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-1	Man	58	30	25	24	18	155
	Women	2	3	4	1	0	10
Total		60	33	29	25	18	165

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.709[a]	4	.222
Likelihood Ratio	6.139	4	.189
Linear-by-Linear Association	.010	1	.921

N of Valid Cases	165		

a. 5 cells (50.0%) have expected count less than 5. The minimum expected count is 1.09.

This question has been asked supposing that women might consider some tools as unimportant rather than men due to their physiology structure. However, and according to the results of the analysis and Chi Square Test, there is no relation between the gender of maintenance staff and their opinion about maintenance toolboxes' weight considering containing unimportant tools or not.

4.2. Department of Maintenance

4.2.1. Inappropriate usage of hand tools

Hypothesis-3: Department (P-2) of Maintenance has an effect on the inappropriate usage of hand tools while doing maintenance (P-14).

To investigate whether "Department" has an effect on the staff's inappropriate use of maintenance hand tools or not. The following analysis has been made.

Table 4.3. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the department of maintenance and the inappropriateness usage of hand tools*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-2 * P-14	165	100.0%	0	0.0%	165	100.0%

Crosstabulation

Count

		P-14					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-2	Avionics	6	9	10	11	6	42
	Mechanical	24	12	22	27	18	103
	Other Shops	3	2	5	7	3	20
Total		33	23	37	45	27	165

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.654[a]	8	.794

Likelihood Ratio	4.499	8	.810
Linear-by-Linear Association	.170	1	.680
N of Valid Cases	165		

a. 4 cells (26.7%) have expected count less than 5. The minimum expected count is 2.79.

This question has been asked to figure out whether the maintenance department has an effect on the maintenance process since every department has its own tool sets, tasks and maintenance approach. According to the results of the analysis and Chi Square Test, there is a slight relationship between the department of maintenance staff and their misuse of maintenance hand tools while working especially for the “Mechanics” department. This can be clearly noticed for both Avionics and Other Shops; this can be explained taking in consideration the "complexity" of such tools compared with basic and simple mechanical ones. In addition, avionics teams deal with more “simplified” tasks such as assembly/disassembly ones where everything has its own installation guides that easiness this process. However, it is not the same case as for the mechanical technicians who have to tackle more “sophisticated” tasks such ranging between driving a screw up to maintain a full engine! Moreover, lack of receiving regular training -as explained in later analysis- is another important reason to be considered to understand this outcome.

4.2.2. Receiving tool box containing damaged tools

Hypothesis-4: It depends on the maintenance department (P-2) when it comes to realize that there are damaged tools when maintenance staff receive their maintenance tool boxes (P-21).

To investigate whether "Department" has an effect on finding damaged tools when receiving their maintenance tool boxes at the beginning of their shifts or not. The following analysis has been made.

Table 4.4. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the department of maintenance and receiving tool boxes with damaged tools*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-2 * P-21	165	100.0%	0	0.0%	165	100.0%

Crosstabulation

Count

		P-21					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-2	Avionics	14	11	8	6	3	42
	Mechanical	39	21	21	19	3	103
	Other Shops	2	3	7	5	3	20
Total		55	35	36	30	9	165

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.272[a]	8	.139
Likelihood Ratio	12.380	8	.135
Linear-by-Linear Association	3.433	1	.064
N of Valid Cases	165		

a. 5 cells (33.3%) have expected count less than 5. The minimum expected count is 1.09.

This question has been asked to know the extent of effect of maintenance department on receiving hand tools boxes with damaged ones supposing that the different type of tools can be damaged in a way or another depending on the task it is made for. According to the results of the analysis and Chi Square Test, it has been noticed that there is a relationship between the department of maintenance staff and the finding of damaged tools while receiving maintenance tool boxes. While this hypothesis is not true for both "Avionics" and "Mechanical" departments, this is a true only for the "Other Shops" departments like Cabin Services, Painting Services and Structural Maintenance. This can be explained by knowing that tools for "Other Shops" are more "shared" among team members other than the tools for other teams.

4.2.3. Teams cooperation

Hypothesis-5: Maintenance Department (P-2) has an effect on the cooperation -lending hand tools- between maintenance team members (P-26).

To investigate whether "Maintenance Department" has an effect on cooperation between a maintenance team members or not. The following analysis has been made excluding students.

Table 4.5. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the department of maintenance and maintenance teams cooperation*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-2 * P-26	165	100.0%	0	0.0%	165	100.0%

Crosstabulation

Count

		P-26					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-2	Avionics	13	9	7	6	7	42
	Mechanical	29	7	18	25	24	103
	Other Shops	7	4	4	3	2	20
Total		49	20	29	34	33	165

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.402[a]	8	.238
Likelihood Ratio	10.424	8	.237
Linear-by-Linear Association	.019	1	.891
N of Valid Cases	165		

a. 4 cells (26.7%) have expected count less than 5. The minimum expected count is 2.42.

The main reason behind investigating this hypothesis is that at maintenance facilities, dozens of mechanics work in different teams simultaneously. This "network" of workers has its own characteristics that reflects on the maintenance processes performance. One of the most important characteristics to be analyzed is the cooperation between team members. According to the results of the analysis and Chi Square Test, it has been noticed that there is a relationship between the departments of maintenance staff cooperation between maintenance team members only for "Mechanics" teams. This can be explained by noticing that maintenance hand tools for mechanics department are so cheap compared with avionics and other departments. That is why mechanical maintenance team members do cooperate with each other while other departments do not.

4.3. Maintenance Organization

In this section, the effect that a maintenance company might have on maintenance process are investigated.

4.3.1. Work environment

Hypothesis-6: There is a significant relationship between the maintenance company (P-6) and the work environment and physical conditions (P-12).

To investigate whether "Maintenance Company" has a direct effect on the work environment and physical conditions. The following analysis has been made to test out the different maintenance facilities that the participants are working at excluding both "Students" and "Unemployed".

Table 4.6. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the maintenance organization and work environment*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-6 * P-12	138	100.0%	0	0.0%	138	100.0%

Crosstabulation

Count

		P-12					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-6	Company A	1	4	16	30	20	71
	Company B	0	0	1	3	6	10
	Company C	0	0	3	1	2	6
	Other	3	3	9	15	21	51
Total		4	7	29	49	49	138

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.190[a]	12	.431
Likelihood Ratio	12.606	12	.398
Linear-by-Linear Association	.009	1	.923
N of Valid Cases	138		

a. 14 cells (70.0%) have expected count less than 5. The minimum expected count is .17.

Work environment is one of the most important factors that directly affect personnel's performance. So, it is vital to understand its effect on the maintenance activities. This is the point behind investigating this hypothesis. According to the results of the analysis and Chi Square Test, it has been noticed that there is a significant relationship between the maintenance company and the work environment and physical conditions that staff are working under. As expected, Company A has the highest score alongside with other participating companies. However, Company C has failed the test meaning that its work environment and physical conditions should be taking under attention to be modified.

4.3.2. Maintenance company "Brand"

Hypothesis-7: There is a relationship between the company that maintenance staff are working at (P-6) and the misuse of hand tools (P-14).

To investigate whether "Maintenance Company" has a direct effect on the misuse of hand tools or not the following analysis has been made excluding "Students" and "Unemployed".

Table 4.7. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the maintenance organization and the misuse of hand tools*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-6 * P-14	138	100.0%	0	0.0%	138	100.0%

Crosstabulation

Count

		P-14					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-6	Company A	6	11	16	24	14	71
	Company B	4	1	1	3	1	10
	Company C	1	1	1	0	3	6
	Other	12	7	14	10	8	51
Total		23	20	32	37	26	138

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)

Pearson Chi-Square	16.818[a]	12	.157
Likelihood Ratio	17.313	12	.138
Linear-by-Linear Association	3.606	1	.058
N of Valid Cases	138		

a. 10 cells (50.0%) have expected count less than 5. The minimum expected count is .87

The maintenance company is considered as one of the most important factors to be analyzed in the maintenance process. As the company does not mean just the brand, it also reflects the maintenance facilities, work environments, level of personnel training … etc. That is why this factor has been discussed in this analysis. According to the results of the analysis and Chi Square Test, it has been found that there is a significant relationship between the company where staff are working at and the misuse of hand tools. Company A has been found to be the company that the most misuse is happening at. This can be explained knowing that training on safe use of hand tools is not regularly run at these maintenance companies.

4.3.3. Teamwork

Hypothesis-8: There is a cooperation between maintenance team members working at the same company (P-6) and (P-26).

To investigate whether is there a relationship between the company that maintenance staff are working at and the cooperation between them or not, the following test has been made excluding "Students" and "Unemployed".

Table 4.8. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the maintenance organization and teamwork*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-6 * P-26	138	100.0%	0	0.0%	138	100.0%

Crosstabulation

Count

		P-26					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-6	Company A	21	8	15	16	11	71
	Company B	0	1	4	2	3	10
	Company C	2	1	0	0	3	6

Other	17	4	7	11	12	51
Total	40	14	26	11	12	51

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.615[a]	12	.326
Likelihood Ratio	17.723	12	.124
Linear-by-Linear Association	.125	1	.724
N of Valid Cases	138		

a. 10 cells (50.0%) have expected count less than 5. The minimum expected count is .61.

Cooperation between team members can be considered as a twofold matter. On one hand, it can be a positive indicator of the maintenance facility's environment that leads to a higher production rate at a better performance. On the other hand, it can be a negative indicator that leads to technicians casting assignments to their colleagues which leads to a lesser production rate and a possible maintenance issues like maintenance faults. This is the main reason that this factor has been analyzed. According to the results of the analysis and Chi Square Test, it has been found that there is a relationship between the maintenance company and the cooperation between team members in general except for Company A. This can be explained by knowing Company A’s own policies towards staff's responsibility for hand tools in addition to the high rivalry level between employees in sake for getting a promotion.

4.3.4. Running of regular trainings

Hypothesis-9: There is a relationship between the maintenance company (P-6) and whether regular trainings on the safe use of hand tools are made or not (P-27).

To investigate whether is there a relationship between the company that maintenance staff are working at and the regular running of training on safe use of hand tools, the following test has been made.

Table 4.9. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the maintenance organization and the running of regular trainings*

Case Processing Summary

	Cases		
	Valid	Missing	Total

	N	Percent	N	Percent	N	Percent
P-6 * P-27	138	100.0%	0	0.0%	138	100.0%

Crosstabulation

Count

		P-27					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-6	Company A	8	22	16	14	11	71
	Company B	1	0	2	1	6	10
	Company C	3	1	1	0	1	6
	Other	4	5	10	14	18	51
Total		16	28	29	29	36	138

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	29.526[a]	12	.003
Likelihood Ratio	28.772	12	.004
Linear-by-Linear Association	7.198	1	.007
N of Valid Cases	138		

a. 10 cells (50.0%) have expected count less than 5. The minimum expected count is .70.

The name of the maintenance company reflects its commitment to a maintenance that is safe, reliable and on time. Conducting regular trainings not only saves time and maintenance materials but also -and to a great extent- enable technicians to simulate real-life issues and challenges. This will end up in providing a maintenance that is fault-free and cost-optimized. These points lie behind running this analysis. According to the results of the analysis and Chi Square Test, in general, it has been noticed that there are regular trainings on the safe use of hand tools are run at such companies. However, Company A has been found to be a company where 50% of its employees have expressed that there are regular trainings to be run where on the other hand the other 50% have expressed the opposite.

4.3.5. Running of awareness activities

Hypothesis-10: There is a relationship between the company that staff are working at (P-6) and whether activities are organized so that staff can understand their responsibilities of tool box safety (P-32).

To investigate whether there is a relationship between the company that maintenance staff are working at and the running of activities so that staff can understand the responsibilities they have towards tool box safety, the following test has been made excluding "Students" and "Unemployed".

Table 4.10. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between the maintenance organization and the running of awareness sessions*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-6 * P-32	138	100.0%	0	0.0%	138	100.0%

Crosstabulation

Count

		P-32					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-6	Company A	5	3	14	23	26	71
	Company B	1	0	0	2	7	10
	Company C	0	0	1	2	3	6
	Other	2	3	10	13	23	51
Total		8	6	25	40	59	138

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.426[a]	12	.828
Likelihood Ratio	9.997	12	.616
Linear-by-Linear Association	.515	1	.473
N of Valid Cases	138		

a. 14 cells (70.0%) have expected count less than 5. The minimum expected count is .26.

Running activities enable maintenance staff to simulate the real situations that they will face in their real-life practices. This is quite important to ensure that all persons in charge all well aware of the responsibilities they have. According to the results of the analysis and Chi Square Test, it has been found that all different companies run their own activities to ensure that their staff understand their responsibilities towards the safety of maintenance toolbox's hand tools.

4.4. Work Experience

4.4.1. Inappropriate use of hand tools

Hypothesis-11: Work experience (P-8) has a direct effect on the inappropriate use of hand tools of maintenance tool boxes (P-14).

To investigate whether is there a relationship between work experience and the misuse of hand tools, the following test has been made excluding "Students".

Table 4.11. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between work experience and the inappropriate use of hand tools*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-8 * P-14	145	100.0%	0	0.0%	145	100.0%

Crosstabulation

Count

		P-14					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-8	1-3 years	16	16	20	23	12	87
	4-6 years	6	3	4	6	3	22
	7-10 years	4	1	5	4	3	17
	11-20 years	2	0	2	2	3	9
	> 20 years	0	0	3	3	4	10
Total		28	20	34	38	25	145

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.619[a]	16	.627
Likelihood Ratio	17.094	16	.380
Linear-by-Linear Association	4.744	1	.029
N of Valid Cases	145		

a. 18 cells (72.0%) have expected count less than 5. The minimum expected count is 1.24.

Work experience can be considered as one -if not the only one- most important factors of maintenance process. Experienced staff not only perform their duties in a unique way and on time but also, they can be a guidance to their less experienced colleagues. This is a quite important factor to be taken in consideration in such an analysis. According to the results of the analysis and Chi Square Test, it is clear that fresh staff; 1-3 years of experience have shown that there is a significant relationship between the misuse of hand tools and work experience. Yet, there is a common agreement on that hand tools can be misused while working regardless of work experience.

4.4.2. Interiority of toolbox design

Hypothesis-12: There is a relationship between work experience (P-8) and the opinion of staff considering the design of toolbox's interiority (P-19).

To investigate whether is there a relationship between work experience and whether staff think that the toolbox's interiority is well designed or not, the following test has been made excluding "Students".

Table 4.12. *Case Processing Summary, Crosstabulation, and Chi-Square Tests for the Investigation of the relationship between work experience and the inappropriate use of hand tools*

Case Processing Summary

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
P-8 * P-19	145	100.0%	0	0.0%	145	100.0%

Crosstabulation

Count

		P-19					Total
		Strongly disagree	Disagree	Neutral	Agree	Strongly agree	
P-8	1-3 years	5	2	9	33	38	87
	4-6 years	0	0	3	9	10	22
	7-10 years	0	0	2	5	10	17
	11-20 years	0	1	1	4	3	9
	> 20 years	0	0	0	4	6	10
Total		5	3	15	55	67	145

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.161[a]	16	.799
Likelihood Ratio	13.114	16	.664
Linear-by-Linear Association	2.057	1	.151

N of Valid Cases	145		

a. 18 cells (72.0%) have expected count less than 5. The minimum expected count is .19.

In every organization, persons in charge have their own opinions on the facilities they deal with. Their opinions shall be considered for any further development or modification that these tools should run. That is why the opinion of such people on the design of tool box design has been analyzed. According to the results of the analysis and Chi Square Test, results show that the toolbox's interiority is designed in a unique way based on maintenance documents.

4.5. Suggestions

Some of the participants in the survey have made suggestions about some issues to be tackled.

- While the tool kit for each department is being prepared, the technicians working in that -unit should be supported in the most serious way. Personnel working in units such as purchasing, etc. should not buy tools without consulting.
- Very unnecessary hand tools should be removed and internal materials should be taken by the chief technician or the person who knows the handbook.
- Each toolkit box should be prepared by the person according to his / her needs.
- Sometimes employees do not realize that the tool kit is missing, so simple warning systems can be used to warn them. Such additional costs can be added to the tool bags prices.
- Maintenance bags can be created according to professional specialization subjects
- A tool-need-based bag shall be a substitute of a standard bag.
- Periodic maintenance of used tools shall be conducted.
- Since the number of employees in the company I work for is high, the maintenance environment is not clean enough and the necessary trainings are not given to employees. Such trainings should be given to ensure a clean environment. For the same reason, maintenance bags are too contaminated with chemicals such as oil and hydraulic. These bags should regularly be checked and cleaned every day and necessary training should be given.
- Some tool bags have defective or damaged tools. Despite the notifications I made, these defective tools are still not repaired when I use maintenance bags again.

- As an avionics systems chief technician, I think it is important to give importance to Team Resource Management (TRM) and Maintenance Resource Management (MRM) trainings to maintenance personnel.
- Tool bags should be ergonomically designed so that tools should not easily fall apart. When using two bags standing next to each other, special markings should be made to avoid mixing tools between them. This is because we often encounter missing tools in the bite sets. For the maintenance environment, educated and conscious people will continue to increase but as if they have not increased and this is because the necessary procedures are not accurately followed.
- By adding a small integrated touch screen to the maintenance bag, missing or malfunction situations can be noted and overlooked can be prevented.
- Maintenance bags can be supported by an electronic system in order to assist in detecting of any missing in the tools bag.
- The maintenance environment to be created or the new tool bags to be bought based on consulting the technician who will use it and listen to the technician's requests and suggestions. It is easier to make additions to the new hangars built in line with the wishes of the technicians and to make them in the initial construction phase. Taking the tool bags to be purchased in sets for the work to be done prevents waste and provides more effective use. As an example, an avionics technician should not be given a bag that other technicians should use. Or, bags should be given to a body technician in sets where he can do the trunk work.
- For bags exceeding 20 kg, a wheeled apparatus should be used to help carry it.
- I think that bags themselves -structures- are heavier than the sum of the materials' weight they contain and they should be lighter. Daily or weekly control of the teams should be made. This includes charging tracking of regular batteries for the rechargeable screwdriver and lights and replacing used lights by charged ones.
- Some maintenance personnel do not know much about what they are supposed to know. Even if maintenance bag is shown to them, most of them do not know about it. This is too much fun!

- It would be wrong to consider a standard maintenance bag. I think it would be more appropriate to classify such bags according to the processes to be applied to the aircraft or equipment.
- Some of our colleagues have been injured because of the too much heavy handbags. On the other hand, avionics maintenance bags are made of a non-durable plastic material so they can break very quickly.
- For years, many hand tools that should be inspected and used have not. They are standing on the shelf in a dusty situation. I even saw a man removing a part of the shaft with his broom handle. Education is a must!
- Maintenance bags MUST be printed.
- The content of the tool bags should be determined according to the missions to be performed and the aircraft type.
- Each part needs a separate tool. The maintenance bag should be prepared based on the needs of the type of operation that the technician will make. This should be made through contacting the determined technician before conducting the maintenance and hence the maintenance bag will be ideal to this operation leading to an easier task that the technician will make and a faster maintenance process.

5. CONCLUSION AND FUTURE RESEARCH

Aviation Maintenance has been one of the most researched topics in the aviation industry. The persistent need alongside its huge business market of aviation maintenance made it goes under ever-developing process. Yet, today's aviation maintenance business still need further focus on all its aspects till reaching the point of getting this industry as optimized and sustainable as possible.

Aviation maintenance industry is an enterprise that depends on many different factors with a great dependency on the human ones. The "relationship" between a maintenance technician and maintenance tools is of a great importance to conduct reliable and safe maintenance tasks. Researchers, psychologists and ergonomists have been doing such a great research to tackle all different issues in this industry.

In this research, the main aircraft maintenance process has been deeply discussed. An introduction regarding organizational commitment in addition to aircraft maintenance operations have been made. Then, a detailed survey tackling all different aspects of maintenance issues have been conducted. Later on, a comprehensive analysis considering all different aspects of aviation maintenance has been made. Finally, some recommendation for the maintenance business and for future research has been presented.

To do this research, a comprehensive survey of different aspects has been made and been contributed to by dozens of aviation students, technicians, engineers and managers of different specialization and experience. Later on, a quantitative study has been made using IBM's last version of its SPSS program investigating the different potential relationships between the topics under research and the contributors to the survey.

To find an answer of the main research's question, many different hypothesis investigating the relationship between maintenance staff and maintenance toolkits have been analyzed and that the physiological nature -gender- has no effect on conducting maintenance tasks in a precise way. On the other hand, a clear relationship between the department of maintenance and the misuse of maintenance hand tools and teams cooperation. This can be justified by understanding the complex nature of such maintenance operations and the accompanied costs and efforts.

Later on, a detailed investigation about the effects that a maintenance organization might have on its own staff has been made and a significant relationship between maintenance organization and its personnel has been found. Many factors have been determined such as providing comfortable work environment in addition to having a unique managing system have been determined and providing such things are vital to profitable run a maintenance organization.

The last topic to be investigated was the relationship between safety culture and the maintenance process and an interesting result has been found when a big difference between maintenance organizations considering running awareness sessions or activities that enable staff to fully understand their responsibilities towards such a business. This point itself has been mentioned in almost every surveyed person who has made his/her own suggestions.

The design of the maintenance tool kit has been under a significant focus since it is the main unit that is used in the maintenance process. Many suggestions can be made to optimize such a unit by either adding an electronic detection system, adding a logging system to it or even making it more task-oriented. Other suggestions considered running awareness sessions and activities to enable maintenance staff to get to know their duties and make them fully understanding the risks related to such tasks. Finally, designing a "task-oriented" toolkit is a promising concept that can improve the maintenance performance through saving time and efforts while dealing with such toolkits.

To sum up, a comprehensive investigation has been made in this research to face today's aviation maintenance industry challenges from the perspective of maintenance personnel. Many different aspects and relationships between maintenance organizations and maintenance staff have been thoroughly investigates. The main aim of this research was to figure out maintenance-related issues and present solutions to it. A quantitative study has been made though this research. However, a qualitative study might support the results gotten.

As a result of this research, a thorough code of conduct has been made that can be applied at any aircraft maintenance school or company that will definitely lead to a higher rate of technician's production and cheaper maintenance cost through saving the hand tools though a higher sensible, aware and wise use of them.

Running this survey through a definite number of aviation staff in a single country might be a limitation of this research. Yet, it has casted the light on the current issues that this sector faces. In addition, running factor analysis is of an importance in order to build a general model that can applied to every maintenance organization. Moreover, spending a bigger focus on taking in consideration the two main maintenance types; Line or Base maintenance can be a future potential topic.

A further research about the urgency of aircraft maintenance procedures especially for unscheduled maintenance can be conducted. Moreover, a research about the supply chain management in aviation maintenance to optimize the process time and efforts can be a unique research in this field. Finally, a similar research can be made considering the military aviation sector that has its own considerations and sensitivities. Such a research can present answers to such issues and it would be of such an importance because of the urgency of having such solution for an army's air force fleet.

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Annex

Annex-1: Questionnaire

The research is carried out by Assistant Professor Savaş S. ATEŞ for scientific and educational purposes. It is aimed to contribute to the development of students and to publish scientific publications by sharing the results of the research with the instructors for the maintenance bag and hand tools.

DEMOGRAPHIC DATA

1. Your Gender
2. Your Department
3. The license category of the exam entered
4. Type of School you graduated from
5. Employment Status of Aeronautics and astronautics
6. Company you are working at
7. If you selected “other”, please write the name of the company
8. How many years have you been working?
9. How many years have you taken the module exams?
10. How many years have you been holding the license?

QUESTIONS ABOUT WORKING CONDITIONS

11. Salary
12. I can easily do my work in the physical working environment and conditions (lighting - heating - order)
13. I have the tools and equipment we need to make maintenance safely.

TOOLKIT BOX AND HAND TOOLS QUESTIONS

14. While working, some hand tools can be used inappropriately
15. My toolkit box is designed to be carried easily
16. The toolkit box is designed so that I can easily find the hand tools
17. I can realize the missing tool thanks to shadow boards
18. The Toolkit box is very heavy because of containing unimportant tools
19. The toolkit box’s interior is conformably designed by a senior technician- or a maintenance manager- like experts based on maintenance documents
20. The toolkit box generally has missing tools

21. Generally, when I receive the toolkit box, I realize that there are damaged tools

22. It is common for hand tools to be damaged during maintenance

23. If I report damaging tool or toolkit box, I would be penalized

24. When tools or toolkit boxes are damaged or worn out, they can be renewed without making notifications

25. Inspections of damaged hand tools are performed regularly in my company

26. If there is a missing in my toolkit box, my colleagues will help me by giving me the missing tools

27. I receive regular trainings on the safe use of hand tools

QUESTIONS OF USAGE AND DAMAGE SOURCES

28. Hand tools and toolkit box get damaged because of lack of quality

29. My Hand tools and toolkit box are damaged and worn out depending on usage

30. There are times when I get angry and despise my hand tools or toolkit box because of unfairness and nepotism.

31. There are times when I throw the toolkit box hard on the ground to show my anger

MAINTENANCE SAFETY CULTURE QUESTIONS

32. Activities (training, memorandum, visuals, etc.) are organized to understand my responsibilities of toolkit box safety.

33. I think it will take a long time for the maintenance safety culture to be changed

34. If you have any suggestions that can improve the maintenance environment and toolkit boxes, please write them.

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Academic Background:

BSc. Aeronautical and Aerospace Engineering - 2014 - University of Aleppo

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