DO-200A STANDARDININ BENİMSENMESİNİ ETKİLEYEN FAKTÖRLERİN İNCELENMESİ

AN INVESTIGATION OF FACTORS AFFECTING THE ADOPTION OF DO-200A STANDARD

SEMİH TERECİ

ASSOC. PROF. DR. MURAT AYDOS

Supervisor

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This thesis is dedicated to the memory of my beloved mother who passed away because of COVID-19.

ABSTRACT

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Semih TERECİ

Master of Science, Computer Enginering Department

Supervisor: Assoc. Prof. Dr. Murat AYDOS

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Software organizations can use standards in the software field in order to reach their targeted quality level, to be a legal requirement or to increase their market shares in line with the accreditation or certification target. On the other hand, compliance with standards becomes more important in the development of safety critical software systems. Therefore, some national or international authority organizations or procurement authorities may seek compliance with certain standards for such software. Software developed for the civil aviation field where safety critical systems are used must comply with the DO-200A Standard. The DO-200A Standard provides guidance with a list of rules to ensure that aviation data is received and processed smoothly and completely and sent to the air platform. It is known that the software industry, which has difficulties in successfully applying software engineering methods and techniques, also faces problems in compliance with standards. Despite the importance of compliance with the standards, no study has been found in the literature to facilitate compliance with the DO-200A Standard. In the study, it is aimed to determine the degree of influence of the factors that may affect the adoption of DO-200A Standard by a software organization. In this thesis, firstly, by using the Systematic Mapping Study (SMS) method, questionnaire-based studies in various databases were investigated and various factors were obtained. Then,

these factors were evaluated by experts in the field of DO-200A Standard to determine which ones are most relevant to the DO-200A Standard. In the interviews, it was aimed to obtain a consensus on the factors that may affect a software organization's adaptation to the DO-200A Standard in a wide range. 34 people experienced in DO-200A Standard participated in the survey aimed at measuring the effect of the final factors obtained. After the descriptive analysis (mean, standard deviation, etc.) of the answers given to this questionnaire and factor mapping of the questions, various results were obtained by calculating the weighted average according to the factors. It is considered that the results obtained will contribute to software practitioners who will benefit from the DO-200A Standard, starting from planning, in increasing the success rate in their journey to compliance with the DO-200A Standard, and will help researchers by providing a general view in their research design studies.

Keywords: standard, adaption, aeronautical, software development, DO-200A

ÖZET

DO-200A STANDARDININ BENİMSENMESİNİ ETKİLEYEN FAKTÖRLERİN İNCELENMESİ

Semih TERECİ

Yüksek Lisans, Bilgisayar Mühendisliği Bölümü

Tez Danışmanı: Doç. Dr. Murat AYDOS

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Yazılım organizasyonları, hedefledikleri kalite seviyesine ulaşmak, akreditasyon veya belgeleme hedefi doğrultusunda, yasal bir zorunluluk olması ya da pazar paylarını artırmak amacıyla yazılım alanındaki standartları kullanabilmektedir. Öte yandan, emniyet kritik yazılım sistemlerinin geliştirilmesinde standartlara uyum daha çok önem kazanmaktadır. Dolayısıyla, ulusal veya uluslararası bazı otorite kuruluşlar veya tedarik makamları bu tür yazılımlar için belli standartlara uygunluk arayabilmektedir. Emniyet kritik sistemlerin kullanıldığı sivil havacılık alanı için geliştirilen yazılımların ise DO-200A Standardı'na uygun olması gerekmektedir. DO-200A Standardı, havacılık verilerinin sorunsuz ve eksiksiz alınıp işlenerek hava platformuna yollanmasını garanti etmek için çeşitli kurallar listesi ile rehberlik sağlar. Yazılım mühendisliği yöntem ve tekniklerini başarı ile uygulamakta zorluklar yaşayan yazılım endüstrisinin standartlara uyum konusunda da problemlerle karşılaştığı bilinmektedir. Standartlara uyumun önemine rağmen, DO-200A Standardına uyumun kolaylaştırılması için yapılan bir çalışmaya literatürde rastlanmamıştır. Çalışmada, bir yazılım organizasyonu tarafından DO-200A Standardı'nın benimsenmesine etki edebilecek faktörlerin etki derecelerinin belirlenmesi amaçlanmıştır. Bu tezde öncelikle Sistematik Eşleme Çalışması yöntemi ile çeşitli veri tabanlarındaki anket tabanlı çalışmalar araştırılmış ve çeşitli faktörler elde

edilmiştir. Ardından bu faktörler, DO-200A Standardı alan uzmanları tarafından hangilerinin DO-200A Standardı ile en çok ilgili olduğunu belirlemek üzere görüşmeler yapılarak değerlendirilmiştir. Yapılan görüşmelerde bir yazılım organizasyonunun DO-200A Standardı'na geniş çerçevede uyum sağlamasına etki edebilecek faktörlerin konsensusa varılarak elde edilmesi amaçlanmıştır. Elde edilen nihai faktörlerin etkisini ölçmeye yönelik ankete DO-200A Standardı konusunda tecrübeli 34 kişi katılım sağlamıştır. Bu ankete verilen cevapların betimsel analizleri (ortalama, standart sapma vb.) ile soruların faktör eşleştirmeleri sonrasında faktörlere göre ağırlıklı ortalama hesapları ile çeşitli sonuçlar elde edilmiştir. Elde edilen sonuçların DO-200A Standardı'ndan faydalanacak yazılım pratisyenlerine planlamadan başlayarak DO-200A Standardı'na uyum yolculuğunda başarı oranını artırmakta katkı sağlayacağı, araştırmacılara ise araştırma tasarımı çalışmalarında genel bir görünüm sağlayarak yardımcı olacağı değerlendirilmektedir.

Anahtar Kelimeler: standart, benimseme, havacılık, yazılım geliştirme, DO-200A

CONTENTS

ABSTRACT i

ACKNOWLEDGEMENTS v

CONTENTS v

TABLES vii

FIGURES viii

ABBREVATIONS ix

1. INTRODUCTION 1

1.1. Overview 1

1.2. Purpose of the Study 4

1.3. Contribution and Outline 5

1.3.1. Main Contributions 5

1.3.2. Thesis Outline 5

2. BACKGROUND 6

2.1. Safety Critical System and Software 6

2.2. Aeronautical Data 7

2.3. DO-200A Standard 8

2.3.1. Verification Process of DO-200A 11

2.4. AC 20-153A 14

2.5. DO-178C Standard 15

3. LITERATURE 17

3.1. Literature Review Method 18

3.2. Definition of Research Question 19

3.3. Searching Strategy 19

3.4. Pre-elimination of Searching Papers 20

3.5. Selecting the Publications by Applying the Determined Criteria 21

3.6. Factor Extraction and Mapping of Studies 22

4. METHODOLOGY 26

4.1. Research Design 27

4.2. Survey (Questionnaire) 28
4.2.1. Survey Structure 29
4.2.2. Survey Process 29
5. DISCUSSION 30
5.1. Phase 1: Demographics 30
5.2. Phase 2: Technical Questions 34
5.2.1. Analysis of Questions According to Weighted Arithmetic Mean Calculation 52
6. CONCLUSION 61
6.1. Comparison of Results 61
6.2. Limitations and Recommendations for Future Work 62
6.2.1. Harmonization of Corporate Knowledge Base 63
6.2.2. Changing the Tightness of the Process According to the Safety Level 64
6.2.3. Documentation Adaptation 64
6.2.4. Required Compatibiliy in Software Development Environment and Tools 65
6.2.5. Gap Analysis 67
7. REFERENCES 68
APPENDICES 71
APPENDIX A – PRIMARY STUDIES 71
APPENDIX B – INSTRUMENT 82

TABLES

Table 2.1. DO-200A Assurance Levels 9
Table 3.1. Search strings and sensitivity rates 20
Table 3.2. Applying determined criteria results 21
Table 3.3. Factor list ant experts' opinions 22
Table 5.1. Frequencies of roles 29
Table 5.2. Distribution of experience with DO-200A according to the answers given.. 34
Table 5.3. Distribution of experience with DO-200A according to the answers given.. 34
Table 5.4. Distribution of experience with DO-200A according to the answers given.. 37
Table 5.5. Distribution of experience with DO-200A according to the answers given.. 44
Table 5.6. Distribution of experience with DO-200A according to the answers given.. 46
Table 5.7. Question - Mean Value Matrix 49
Table 5.8. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 52
Table 5.9. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 53
Table 5.10. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 54
Table 5.11. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 54
Table 5.12. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 55
Table 5.13. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 56
Table 5.14. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 56
Table 5.15. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix 58

FIGURES

Figure 1.1. Software in military aircraft....2
Figure 1.2. Growth of software volume in civil aircraft....3
Figure 2.1. Typical aeronautical data chain....9
Figure 2.2. Software Verification Methods....12
Figure 2.3. Static Verification Methods in Safety Critical Software....13
Figure 3.1. The systematic mapping process....18
Figure 3.2. Publications time range....21
Figure 5.1. Bar chart of the distribution of roles....29
Figure 5.2. Bar chart on whether to train or not....30
Figure 5.3. Total Experience of Software....31
Figure 5.4. Total Experience of Aviation....31
Figure 5.5. First meeting the DO-200A Standard....32
Figure 5.6. Total experience with DO-200A Standard....32
Figure 6.1. Comparison of factors....61

ABBREVATIONS

AC	Advisory Circular
CRC	Cyclic Redundancy Check or Cyclic Redundancy Code
COTS	Commercial Off-The-Shelf
DAL	Design Assurance Level
DER	Designated Engineering Representative
DO	Document
EUROCAE	European Organisation for Civil Aviation Equipment
FAA	US Federal Aviation Administration
ICAO	International Civil Aviation Organization
LOA	Letter of Acceptance
NASA	National Aeronautics and Space Administration
RTCA	Radio Technical Commission for Aeronautics
SMS	Systematic Mapping Study
SW	Software
TQ	Tool Qualification
TQL	Tool Qualification Level
V&V	Verification and Validation

1. INTRODUCTION

1.1. Overview

The increasing place and importance of software in our lives is accelerating the studies on software, and this situation reveals new software engineering paradigms, software development methods, programming languages and tools. Despite all these developments, problems such as falling behind the planned schedule in software projects, exceeding the budget, low quality, inability to provide continuity and reliability, and inability to meet user demands are frequently encountered.

Successful completion of software projects is critical for all project stakeholders. Unfortunately, as in the world, many software projects in our country are completed late, exceeding the foreseen budget and / or without fully meeting the user's expectations, or canceled before completion or cannot be used even though they are delivered. In the literature, the success and failure of software projects have been the subject of many studies [1].

Software plays a critical role in the overall safety chain in many domains, such as aviation, nuclear energy, healthcare or space technologies. Products developed in these industries generally have safety-critical software whose failure might lead to loss of life or extensive environmental damage.

In the future, it is expected that the effect of such software in these products will increase dramatically. Software organizations can use standards in the software field in order to reach their targeted quality level, to meet a legal requirement or to increase their market shares in line with the accreditation or certification target. Moreover, compliance with the standards might be a major issue in the development of safety critical software systems.

The development of avionics systems is usually subject to a regulated environment. A software development error can directly cause loss of human lives or might result other catastrophic consequences. Some examples include systems that control aircrafts, nuclear reactors, and medical devices. The correctness of such software needs to be demonstrated with high assurance. Regulatory agencies expect stringent certification requirements to be met in products developed for safety-critical industries. Development of safety-critical software requires robust software processes for analysis, technical

solution, verification and validation, configuration management, and quality assurance. In modern avionics, the system functions are usually implemented by some complicated computer software [2]. The progress of computer and software has changed the aviation industry [3]. Nowadays, many safety-critical systems and functions are implemented and controlled by computer and software in modern aircraft. According to the National Aeronautics and Space Administration (NASA) study of flight software complexity, the percent of function which provided by software in military aircraft has risen from 8% in 1960 to 80% in 2000, as shows in Figure 1.1. The software size has grown rapidly, and the 8 software size has increased from 1000 lines of code to 1.7M lines of code. For example, the F-22 has 2.5M lines of code [4].

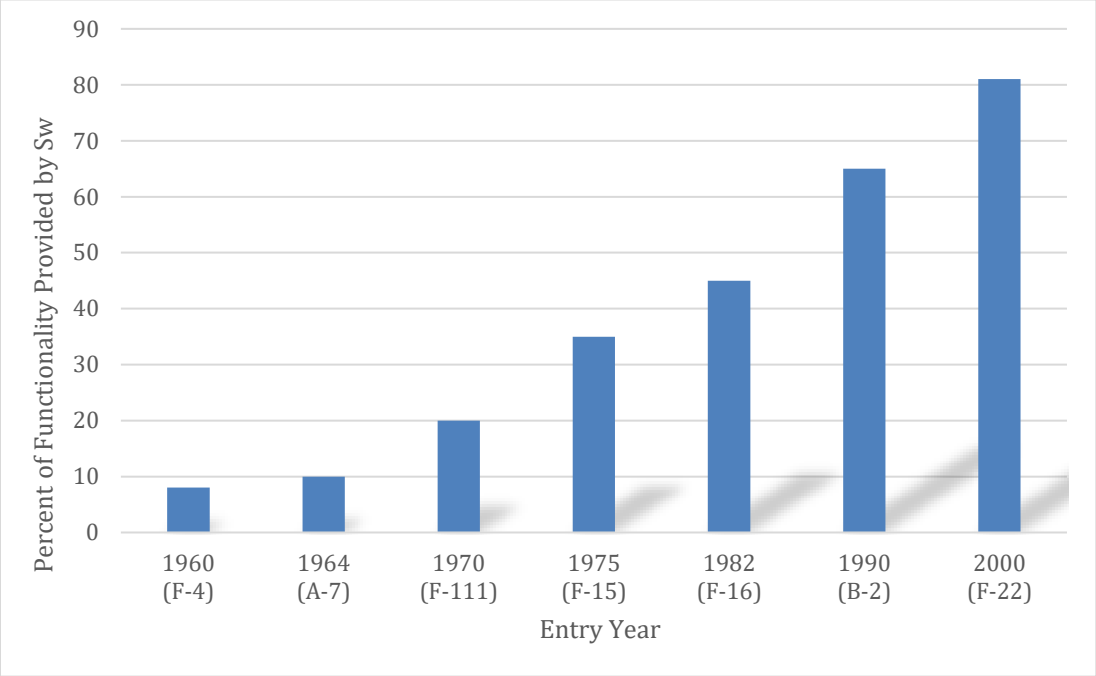

Figure 1.1. Software in military aircraft [4]

Same as the military, many airborne systems and functions, especially the safety-critical systems and functions, have been implemented by software in civil aircraft. According to the journal from Aerospace Lab [5], the airborne system has been changed a lot because of the development of computer and software technology over the last 30 years, and software volume has grown rapidly in these years. For example, avionics system in Airbus A380 has more than 100 million lines of code. The Figure 1.2. shows the growth of software volume in different types of Airbus aircraft. The reason of software volume

growth is easy to understand, because faster computer and software can achieve more flexibility of the aviation system. Since the widespread use of software, the engineer has been concerned with the software failure and its implication for related safety-critical functions. If one software is unsafe and people trust a lot, the destruction of software failure can be erroneous [6]. Even the smallest error can cause the most severe consequence, which might lead to significant damage or loss of life.

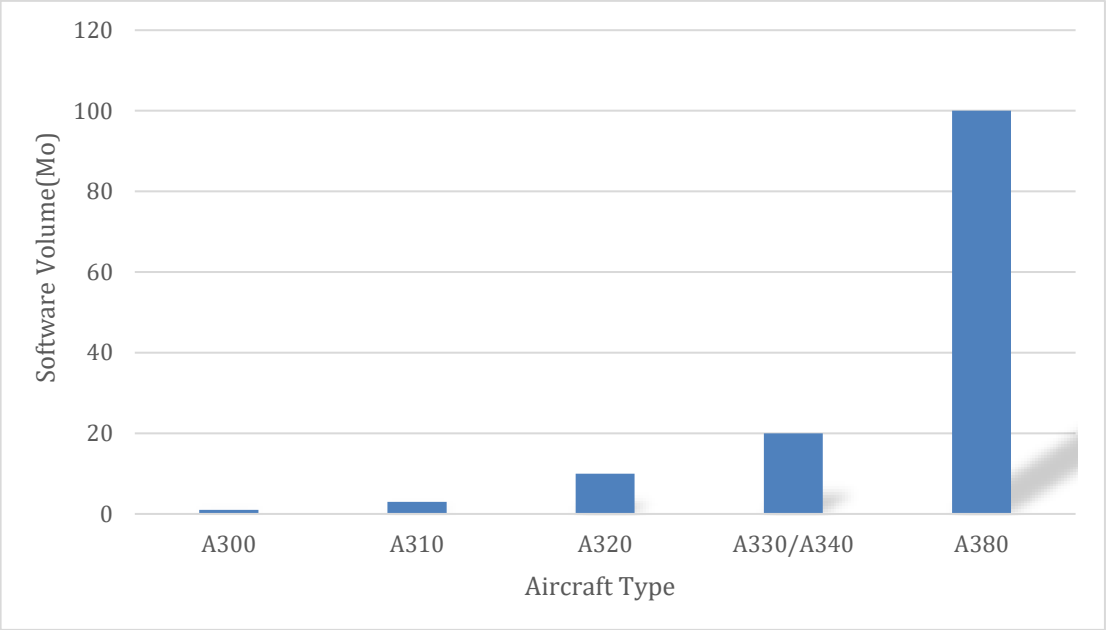

Figure 1.2. Growth of software volume in civil aircraft [5]

Over the years, several commentators have raised concerns about unsafe data. They pointed out that despite the potentially harmful effects of bad data, the issue was covered poorly in mainstream standards, with little guidance available about how to manage the risks that could arise from them. Systems can use data to describe the environment that they interact with, or their own physical configuration. Data can also be used to direct how systems behave, in a manner similar to software. When data determines some of the behaviour of a system, that data may affect safety at the system level. Data can be bad for a number of reasons. It may be generated incorrectly, with bad values or formatting; it may be corrupted intransmission or storage, or it may become stale through changes in the real-world values it represents. Just as design flaws in software can make a system behave unsafely without any hardware fault, bad data can cause unsafe behaviour without any fault in either the hardware or software. And, as with

software, the overall system can often be too complicated for safety to be shown through testing alone [7].

The society has become more and more reliant on safety-critical software and aeronautical databases. Therefore, efforts to ensure safety-critical software and aeronautical database intensive systems must be managed in a reliable and safe manner. The aviation industry has a relatively good track record, but as size, complexity and criticality increase, serious problems may occur. Thus, standardization is required to reflect best practices and also industry knowledge and experience.

Various standards and software lifecycle processes to develop and produce software products at a reproducible and measurable quality level have been defined. Software development organizations follow software lifecycle processes to produce and demonstrate their products at a certain quality level. Moreover, they might use a software development standard during enactment of processes. DO-200A is one of these standards / the guiding document for safety critical software to process aviation data smoothly and send it to the air platform.

Any data to be acquired, processed, and loaded onto an aircraft system should comply with this standard, as well as guidance provided in document. The primary intents are to assure that (a) the data provided meets all of the requirements for its intended use, and (b) data has not been altered or corrupted since origination.

1.2. Purpose of the Study

When we set out on this thesis, the first was to develop a tool that automatically applies all the steps of the DO-200A Standard and to qualify this tool. However, over time, the size of the work to be done, the confidentiality of the data to be used, etc. This goal was abandoned due to circumstances. The next goal was to reveal the difficulties experienced by the organizations dealing with compliance with the DO-200A Standard and the factors / situations that affect their compliance with this standard. As a result, the primary purpose of this study was to examine the factors that affect DO-200A Standard adoption. With this aim, a research model that explains DO-200A Standard adoption of the users was developed.

Thus, thesis sought to address the following research questions:

RQ1: Which factors might affect the adoption of DO-200A Standard?

RQ1a: Which factors have been investigated for the adoption of standards related to software engineering in a software development organization in the literature?

RQ2: What is the effect of selected factors on the adoption of DO-200A Standard?

1.3. Contribution and Outline

1.3.1. Main Contributions

The main contributions of this study are

- To establish the base of DO-200A Standard adoption in the literature
- To reveal the problems encountered in practice in the defense industry, certification and compliance difficulties in this context
- To eliminate the lack of such a study at the academic level with this study
- To contribute the achievement of a high quality level of aviation software.

1.3.2. Thesis Outline

This thesis is organized in five parts: Introduction (Chapter 1), Background (Chapter 2), Related Work (Chapter 3), Methodology (Chapter 4), Discussion (Chapter 5), and Conclusion (Chapter 6). Following this Introduction, the Background and Literature chapters expand the context in which this thesis is framed and provides the state of the art. The next chapter describes the methodology our proposal. Detailed explanation of each step in research model was presented in Figure 4.1. Next section, detailed analysis and discussion of the results of the data obtained as a result of the survey has been made. Final Chapter titled Conclusion, summarizes all the achievements in the research, and points out the relevant work which has not been fully solved in this research.

2. BACKGROUND

In order to determine and understand the factors affecting compliance with the D0-200A Standard, it is necessary to know detailed information about safety critical system and software, DO-200A Standard and DO-178C Standard. Therefore, these details will be discussed in this section. In the first part, since the DO-200A Standard is a standard applied for safety critical systems and software, it will be looked at what such systems and software are. In the second section, details of DO-200A Standard will be discussed. Next, AC 20-153A is a standard complementary to DO-200A, it will be mentioned. In the last part, DO-178C Standard, which is the equivalent of the DO-200A Standard on the aircraft, which ensures the accuracy and error-free of the data sent to the aircraft in accordance with the DO-200A Standard in ground systems and software, will be mentioned. In aviation, there are two types of embedded databases: Airborne System Databases and Aeronautical Databases. Airborne System Databases are typically approved under DO-178C. Aeronautical Databases are typically not approved under type designs of aircrafts. These databases are used by airborne systems, which development processes are typically approved using the guidance of the DO-200A. In the light of this information, the basic differences of these two standards, which are often confused, and what they are used for, will be more understandable [8].

2.1. Safety Cricitcal System and Software

Safety-critical system, in case of any faulty accident:

- Loss of life or serious injury,
- Loss or serious damage to equipment,
- It is a system that can cause serious damage to the environment. Safety-critical software is the software used in these systems. The use of security software is increasing day by day.

Safety-critical software is also used in weapon systems used in vehicles such as land / air / sea, spacecraft and aircraft, helicopters and high-speed ships. Errors that may occur in security-critical systems can be caused by software, hardware or human factors. Therefore, it is particularly important to develop and verify security-critical software used

in the automation of such systems. Detecting a bug in software is often more difficult than detecting a hardware failure. Since possible errors in safety-critical software can disable the hardware on which the software runs and cause dangerous consequences, such software should be passed through a systematic verification process before being used. In the late 1970s, software equipment began to take its place in aviation, raising the question of how software should be rated for airworthiness. Over time, it has been understood that the functional controls performed in the laboratory environment or on the aircraft are not sufficient and the software development process should be reviewed while evaluating this equipment. This situation, as it has been mentioned in this study, has enabled new standards or certifications to be published by the established committees and now become a standard and used in military aviation or civil aviation.

2.2. Aeronautical Data

Aeronautical data are "data used for aeronautical applications such as navigation, flight planning, flight simulators, terrain awareness and other purposes, which comprises navigation data and terrain and obstacle data" [9]. An aeronautical database is "a collection of data that is organized and arranged for ease of electronic storage and retrieval in a system that supports airborne or ground-based aeronautical applications" [9].

Aeronautical data are treated differently than the configuration data that are approved as part of the aircraft's type design data. However, aeronautical data are often not part of the type design data. Instead, loading such data is frequently treated as a maintenance action that is identified in the aircraft's Instructions for Continued Airworthiness. There are at least a couple of reasons that aeronautical data are treated differently than configuration data.First, aeronautical data typically require frequent updates that are not practical to implement under the type certification process. For example, navigation databases are updated every 28 days. To go through the DO-178C software approval process and supplemental type certification or amended type certification every 28 days is virtually impossible. Terrain databases are updated less frequently (perhaps three or four times per year), which is still too frequent for the DO-178C process to be viable. Second, the source of the data for such databases is often a government organization rather than an avionics or aircraft manufacturer. The International Civil Aviation Organization (ICAO) Annex 15 places requirements on the ICAO contracting states around the world that are

responsible for compiling and transmitting the aeronautical data through Aeronautical Information Publications [10]. “Each Contracting State must take all necessary measures to ensure that the aeronautical information / data it provides is adequate, of required quality (accuracy, resolution and integrity) and provided in a timely manner for the entire territory that the State is responsible for” [9]. In the past, ICAO requirements were primarily applicable to navigational data. Recently, terrain data requirements have also been included in the ICAO requirements. DO-178C does not generally apply to aeronautical data. However, RTCA DO-200A, entitled Standards for Processing Aeronautical Data, does apply to this kind of data. Although DO-200A is a descendant of DO-178, it not a copy of DO-178. In fact, DO-200A demonstrates a completely different type of principle, in which the data quality is maintained, ensured, and provided across the data processing sequence.

2.3. DO-200A

Before starting what the DO-200A Standard is, it is necessary to know what the DO means, although it is not of great importance. The designation DO stands for "DOcument".

The Radio Technical Commission for Aeronautics (RTCA)’s DO-200A is recognized as the standard for ensuring the quality of aeronautical data. DO-200A is considered the minimum standard and guidance to address the processing quality assurance and data quality management of aeronautical data used for navigation, flight planning, terrain awareness, flight simulators, etc. The output of the DO-200A compliant process is a database that is distributed to the user for implementation in their equipment [9].

DO-200A identifies requirements and recommendations to provide the appropriate assurance level for the aeronautical data. DO-200A defines assurance level as “the degree of confidence that a data element is not corrupted while stored or in transit. This can be categorized into three levels: 1, 2, and 3; with 1 being the highest degree of confidence” [9]. As with the DO-178C software levels, DO-200A assurance levels are determined by the potential impact of corrupted data on safety.

Table 2.1 DO-200A Assurance Levels

DO-200A Assurance Level	Related Requirement on State-Provided Data(ICAO)	Failure Condition Category	DAL or SW Level
1	Critical	Catastrophic or hazardous / severe major	A, B
2	Essential	Major or minor	C, D
3	Routine	No safety effect	E

Table 2.1. shows the three DO-200A assurance levels and their relationship to the ICAO criticality levels and the failure condition categories. The related design assurance levels (DALs) or software levels are also shown. The ICAO classifications of critical, essential, and routine are defined as follows [12]:

- Critical data (Assurance Level 1): Even the slightest mistake kills crew and passengers.
- Essential data (Assurance Level 2): Some errors that may occur can endanger the lives of the crew or passengers.
- Routine data (Assurance Level 3): It does not cause any negativity.

DO-200A uses the concept of an aeronautical data chain to explain the path that the aeronautical data takes: “An aeronautical data chain is a series of interrelated links wherein each link provides a function that facilitates the origination, transmission, and use of aeronautical data for a specific purpose” [9]. Figure 2.1. illustrates a typical aeronautical data chain.

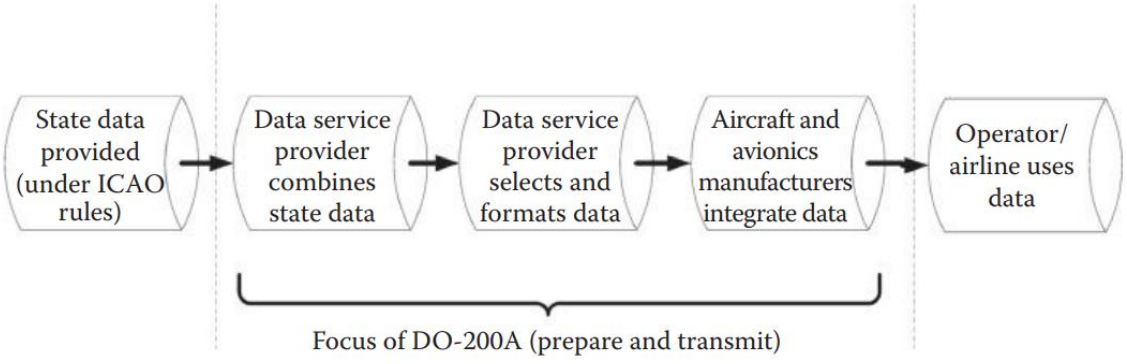

Figure 2.1. Typical aeronautical data chain

At each link in the aeronautical data chain, the data should satisfy the following seven quality characteristics based upon the intended function that will use the data:

1. Accuracy: The degree of conformance between the estimated or measured value and its true value
2. Resolution: The number of units or digits to which a measured or calculated value is expressed and used
3. Assurance Level: The degree of confidence that a data element is not corrupted while stored or in transmission
4. Traceability: The degree that a system or a data product can provide a record of the changes made to that product and thereby enable an audit trail to be followed from the end-user to the data originator
5. Timeliness: The degree of confidence that the data is applicable to the period of its intended use
6. Completeness: The degree of confidence that all of the data needed to support the intended use is provided
7. Format: The structure of data elements, records and files arranged to meet standards, specifications or data quality requirements

At each phase of the processing, the data are verified and any issues are documented in an error report. Corrective action is taken as needed. If the data from a trusted source, such as an ICAO member state, are found to have an error, the error must be reported to the trusted source. However, it is often difficult to get the trusted source to immediately correct the data. Oftentimes, once the data are confirmed to be erroneous, they are corrected by the organization that applies the DO-200A compliant process.

Depending on the assurance level, the amount of required validation and verification varies. Various V & V methods applied by institutions in order to comply with DO-200A are as follows [13]:

- Validation of Timeliness
- Validation of Completeness
- Logical Validation
- Semantic Validation
- CRC Verification
- Verification by Notation

- Verification by Analysis
- Certification of COTS products according to DO-200A or harmonization with the standard

Commercial Off-The-Shelf (COTS), that is, the statement of ready-to-market material describes products that can be used in defense programs and are commercially available after they are manufactured. In addition to these methods;

- Notation methods in the relevant section of the test procedure,
- Binary verification steps of the test procedure,
- Opened articles about DO-200A in the code review tool

are verified by the developer and test experts in accordance with the procedures specified in the previously prepared compliance documents. The audits of these verifications are carried out by the application integrator institutions that will ensure the integration of the processed aviation data and the authority designated by the state as a controller. A significant part of the items in the DO-200A audit actually includes questioning the processes that should be enacted in a CMMI Level 3 company. Approaches related to the technical parts are specified in the compliance documents. To comply with the DO-200A requirements in an audit, the process items are opened for the problems detected by the control group. Control group is typically formed by the Project Manager, Technical Manager, Engineering Team Representative, Quality Engineer, Configuration Manager, and the solution of these items is followed and then these items are closed.
Organizations using such standards are institutions with military secrecy. Since this information cannot be learned due to confidentiality, it is not known which institutions or how many institutions meet this standard. The new version of DO-200A, DO-200B, the most up-to-date standard in the processing of aeronautical data worldwide, is preferred in an increasing trend. The RTCA DO-200B provides minimum requirements for all phases of the data process applicable to the processing of aeronautical data, including quality assurance.

2.3.1. Verification Process of DO-200A

The verification process is the process that reveals that the developed system is exactly the desired system, that it performs the expected behaviors, and that the system does not

have undesirable features and does not show undesirable behavior. In software development, it must be decided that the developed system fully meets customer requirements and that the outputs at each stage of software development are correct. This decision making process is the software validation process. Verification process is one of the most important processes in software development for such reasons. Thus, it is ensured that the software works flawlessly. The main purpose of the software verification process is to reveal possible errors in the developed software and to take necessary corrective actions at the end of them. Planning and implementation of this process should be initiated as early as possible in the software development process [14]. The software verification process in software projects is carried out in two stages. These are reviews and software tests.

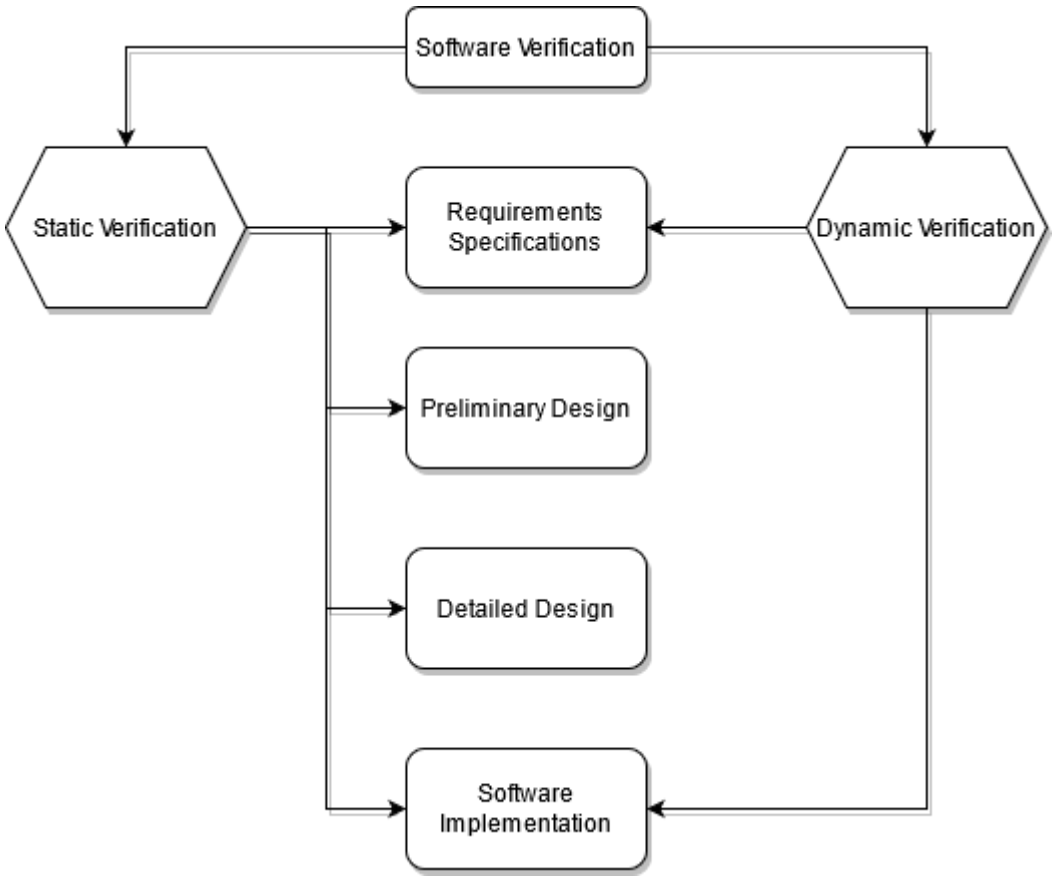

Figure 2.2. Software Verification Methods

We can say briefly as follows. Figure 2.2. shows schematically the software verification process. Static verification deals with every phase of the software life cycle, while dynamic verification deals only with the software developed. Static verification; While managerial review is performed by various review techniques such as technical review,

inspection, inspection, dynamic verification is carried out with tests such as functional, iteration, performance, loading, stress, security. Static verification includes the steps shown in Figure 2.3.

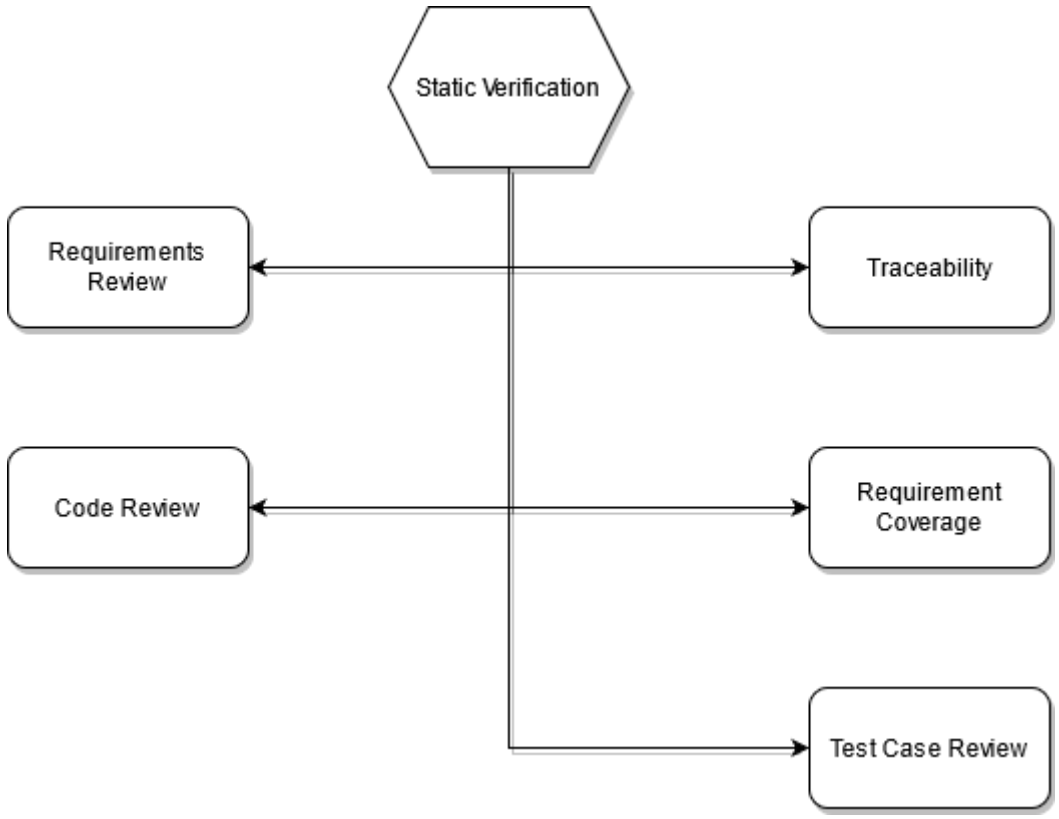

Figure 2.3. Static Verification Methods in Safety Critical Software

If the requirements are not reviewed, the deficiencies or contradictions in the requirement will either go unnoticed or will only be detected in the advanced stages of the software life cycle. One of the purposes of the requirement review is to determine whether the requirement includes sufficient detail to carry out design, validation, and testing.

Dynamic verification is carried out with test actions after the software development is completed. The purpose of software tests performed in software projects is to reveal the existence of errors [15]. A successful test is a test that allows one or more errors to be found. Both should be used together in the software validation process. Since the reviews are checking the conformity of the software to the specifications and standards, this verification method cannot control functional and non-functional features such as performance and security.

The main purpose of the verification process of safety-critical software is to ensure that the software works flawlessly and is developed reliably. The verification process for

safety-critical software is performed within the scope of static and dynamic verification, as in the verification process in non-safety-critical software. However, in the verification of such software, traceability, additional reviews and coverage analyzes are performed in addition to the existing reviews.

2.4. AC 20-153A

Just as the previous section provided an overview of DO-200A, this section includes a summary of FAA AC (Advisory Circular) 20-153A. AC 20-153 (the predecessor to AC 20-153A) only applied to navigation databases. In 2010, the FAA expanded the AC to apply to other types of aeronautical data, including terrain, obstacle, and airport map databases. Each of the databases covered by AC 20-153 is briefly explained as follows. The AC may be applied to other databases; however, those should be closely coordinated with the certification authority [16].

- Navigation database: "Any navigation data stored electronically in a system supporting navigation applications. Navigation data is information intended to be used to assist the pilot to identify the aircraft's position with respect to flight plans, ground reference points and navaid fixes as well as items on the airport surface" [10].
- Terrain database: "Any data stored electronically in a system supporting terrain applications. Terrain data includes the natural surface of the earth excluding man-made obstacles" [10].
- Obstacle database: "Any data stored electronically in a system supporting obstacle applications. Obstacle data includes any natural or manmade fixed object which has vertical significance in relation to adjacent and surrounding features and which is considered as a potential hazard to the safe passage of aircraft" [10].
- Airport map database: "Any navigation data stored electronically in a system supporting airport map applications. Airport map data is information intended to be used to assist the pilot to identify the aircraft's position with respect to items on the airport surface" [10].

AC 20-153A provides guidance to aeronautical service providers, equipment or avionics manufacturers, and / or operators necessary to obtain a letter of acceptance (LOA). An LOA is a letter granted by the FAA, acknowledging compliance with AC 20-153A and

DO-200A for aeronautical data processing. “The LOA formally documents that a supplier’s databases are being produced pursuant to RTCA/DO-200A, or for some established systems, RTCA/DO-200” [10].

2.5. DO-178C

We also wanted to mention the DO-178C Standard because of its continuous mixing. The aim of DO-178C is to produce software that is validated and verified for its airworthiness i.e. reliability and safe-to-use in flight. DO-178C is a conceptual guideline identifying the set of best practices to take into consideration during the development of software for airborne systems and equipment. These best practices are stated in the form of objectives, which have to be achieved by carrying out a set of explicitly defined activities that will output the acceptable evidence (e.g., plans, requirements, design description), known as data items. The amount of objectives for which compliance must be demonstrated depends on the software’s design assurance level (software level for short). The software level describes the severity of the system’s failure conditions to which the software may contribute. DO-178C defines five software levels labeled A through E, with level A being the most rigorous as it requires all the objectives to be achieved and level E the least rigorous as it requires no objectives.

- Level A is assigned to catastrophic effects, meaning a failure may cause multiple fatalities and even the loss of the aircraft.
- Level B is assigned to hazardous / severe major effects, meaning a failure will have a large negative effect on safety or performance causing harm to the occupants or reducing thecrew’s ability to operate the aircraft.
- Level C is assigned to major effects, meaning a failure will have a significant negative effecton safety causing inconveniences to the occupants and an increase in the crew’s workload.
- Level D is assigned to minor effects, meaning a failure will have a slightly negative effect onsafety causing some inconvenience to the occupants and an increase in the crew’s workload.
- Level E is assigned when a failure will have no effect on safety.

DO-178C prescribes a software life cycle comprised of the following three process groups:1) software planning process, 2) software development processes that include

software requirements, software design, software coding and software integration, and 3) transverse processes.

3. LITERATURE

In order to determine and understand the factors affecting compliance with the DO-200A Standard, in this section, the studies conducted on the standards and the studies investigating the factors affecting the compliance with the standards will be mentioned.

There are still important problems regarding implementation of DO-200A Standard. Despite the importance of compliance with the standards, no study has been found in the literature to facilitate compliance with the DO-200A Standard. The aim of the study is to determine the factors that may affect the adoption of the DO-200A Standard in a software organization. In this study, questionnaire-based studies in various databases were investigated using Systematic Mapping Study method. Systematic Mapping Study were developed in different sciences to reliably catalogue evidence on a specific subject. Rather than providing answers to specific questions of impacts, aim to focus searchable databases of studies, along with detailed descriptive information. The maps that gained can prove highly useful for research, policy and practice communities, by providing assessments of knowledge gaps, knowledge gluts, and patterns across the research literature that promote best practice and direct research resources towards the highest quality research. There are studies which aim to guide organizations for successful implemantation of software engineering standards [13, 18, 19]. Factors such as creation of appropriate infrastructure, lack of communication, perception of importance & lack of motivation, attention to cultural differences, lack of training were obtained in the study of de Farias, I. et al [19].

Software organizations need to reflect changes regarding implemantation of standards to their quality mangement system which includes process models. Thus, understandable process models are needed for knowledge workers in order to enact updated processes effectively. There are two recent systematic literature reviews conducted by Dikici A. et al. [20] and Figl, K. [21] which examine the factors that affect understandability of process models.

Global Software Development is defined as a discipline in which software engineering activities are performed in an environment where the teams are distributed through geographical boundaries. Accordingly, the main factors in the failure of software development teams were revealed in [22]. Again, it was thought that it would be useful to consider these factors in order to get a different perspective.

In Gurusamy's study [23], a questionnaire based study aims to highlight factors that prohibit adoption of Open Source Software (OSS) specifically from public sector organizations. Key findings include the "perceived lack of availability of support and training to sustain long-term usage, economical disadvantages associated with OSS applications such as higher support, maintenance and training costs, lack of product quality, inability to meet organizational business needs and legal issues with licensing and intellectual property". Compatibility with existing systems and complexity were also found to influence the decision and result.

According to [24] indicated that the lack of or inadequate communication risk factor which is the factor we have obtained from the most sources as a result of SMS had a high impact. This refers to communication problems on a project that impact project success. There are several reasons we would expect communication risk to be higher on virtual projects.

Dinçer and Garousi created a probabilistic fit model based on critical success factors for the software development model, and as a result, they made root-cause analysis of the failure reasons of the project [25]. One of the problems they encountered as a result of root-cause analysis is that the software was not developed according to the appropriate certifications and standards. Unsuccessful projects were not developed according to a defined formal software development methodology. This is mostly due to the project team's lack of general software engineering knowledge and experience of standards compliance.

3.1. Literature Review Method

In this study, Systematic Mapping Study has been used to determine the scope in the certain field, and to combine the results in answering the research questions more specifically to structure the results by a high level analysis. There are five steps in Systematic Mapping Study including defining the research question, searching the relevant papers, filtering the papers based on the abstract, keywords, and title, selecting publications according to inclusion / exclusion criteria and mapping the factor extraction. Figure 3.1. shows the steps in the method of Systematic Mapping Study. The following steps mentioned in this study have been adapted for research:

1. Defining research questions
2. Searching in digital libraries and other sources to reach publications on the subject and determining the publications to be examined
3. Pre-elimination of papers
4. Selecting the publications by applying the determined criteria
5. Factor extraction and mapping
    a. Determining factors according to research questions
    b. Extraction the publication dates, related fields, study types and publication types to be used for classification by scanning the contents of the publications mapping according to factors and these classification filters.

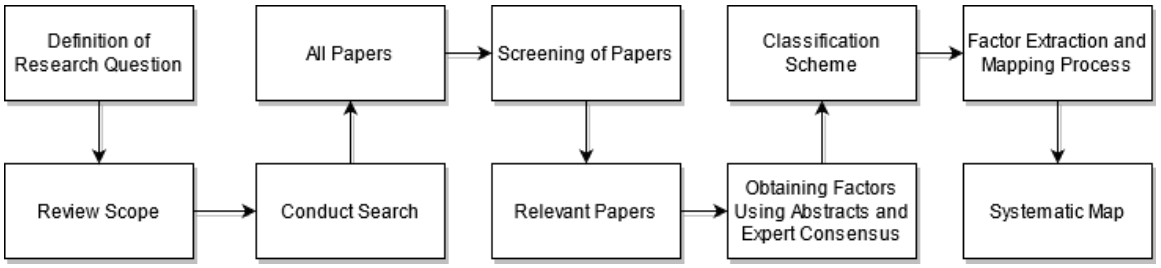

Figure 3.1. The systematic mapping process (adapted from Petersen et al. [26])

3.2. Definition of Research Question

In fact, in this section, an answer to RQ1a, one of the research questions of the thesis previously defined, is sought. In this direction, SMS was applied. Expert opinions were received for RQ1.

3.3. Searching Strategy

After determining the research questions, search queries consisting of various keywords were determined by trial and error to access the relevant articles and pre-elimination was made with these queries. The search has been performed in the following digital databases:

- ACM Digital Library
- IEEExplore

- ScienceDirect
- Springer Link

These digital libraries were selected since they have been confirmed to cover relevant journals and conference and workshop proceedings within software engineering [27].

3.4. Pre-elimination of Searching Papers

After the determination of the search strings, the strings that are obtained through various trial and error will be pre-eliminated. After this pre-elimination, manual searches are made with inclusion criteria determined in digital databases. After all these searches, relevant publications are obtained. The integrity of the search strategy was achieved by comparing the primary studies identified with the manual search process. This comparison was carried out through the application of sensitivity metric. Sensitivity (also named Recall in some studies) is the proportion of relevant studies retrieved all studies for that topic [28]. It can be calculated using Equation 1.

$$\text{Sensitivity} = \frac{\text{Number of relevant studies retrieved}}{\text{Total number of relevant studies}} * 100\% \qquad (1)$$

With the queries shown in Table 3.1., researches have been conducted in four databases mentioned in Section 3.3. After the searches, the sensitivity rates in Table 3.1. have been obtained with the formulations specified before. Papers thought to be relevant to the subject were included in the pool by looking at their titles, abstracts and keywords. The search strings that are considered to obtain the most relevant results under this consideration are given in Table 3.1. After pre-elimination;

standard AND (adoption OR adaptation OR barrier OR driver OR challenge OR factor OR motivation) AND (survey OR questionnaire) AND aeronautical

query pattern has emerged, with a publication related to 65% sensitivity.

Table 3.1. Search strings and sensitivity rates

Search String	Sensitivity
standard AND (adoption OR adopting OR adaptation OR barrier OR driver OR challenge OR factor OR motivator) AND "software development" AND (survey OR questionnaire)	24%
("software quality" OR standard) AND (adoption OR adopting OR adaptation OR barrier OR driver OR challenge OR factor OR motivator) AND (survey OR questionnaire) AND (aviation OR aeronautical)	37%
("software quality" OR standard) AND (adoption OR adopting OR adaptation OR barrier OR driver OR challenge OR factor OR motivator) AND (survey OR questionnaire) AND ("safety critical" OR aviation OR aeronautical)	48%
standard AND (adoption OR adopting OR adaptation OR barrier OR driver OR challenge OR factor OR motivator) AND (survey OR questionnaire) AND aeronautical	65%

3.5. Selecting the Publications by Applying the Determined Criteria

Keyword was applied to search the paper based on the title, abstract and content that correspond to the research databases namely From the result of the automatic paper searching in the research database, 90 papers have been obtained with the following details: 2 from IEEExplore, 20 from ACM, 40 from Science Direct, and 28 from Springer Link. Once taking the results, we applied the selection criteria to filter the candidates. All papers obtained from the research database would be selected based on the inclusion criteria that were used to limit the scope area obtained from Systematic Mapping Study. The elimination process was conducted to reselect or for the exclusion of content in the inclusion area. After searching and filtering the paper, 90 relevant papers were obtained as in Table 3.2. Reference information for the 90 primary studies obtained is given in Appendix A. The inclusion criteria considered throughout Systematic Mapping Study is as follows:

- Should be published in the form of a thesis or in a journal, conference or workshop,

- Should be written in English,

- Should be questionnaire-based to seek factors that affects the adoption of standards, process models etc.,

- Should be conducted to find out the factors that affects the adoption of a standard regarding software development in a software organization,

- Should have been published within the last 30 years,

Table 3.2. Applying determined criteria results

Source	Search Results	Irrelevant	Duplicate	Relevant
IEEE	2	0	0	2
ACM	107	25	12	20
Science Direct	134	55	39	40
Springer Link	64	17	29	28
Total	**307**	**97**	**156**	**90**

Also, the distribution of these articles by years is shown in Figure 3.2. Although the studies on the compliance of the standards by the organizations have been concentrated in certain years, it has been seen that it has increased its popularity in recent years. Since there is very little work on the application and compliance of standards in the market, especially on aviation, the research interval by years was chosen as a wide range of 30 years.

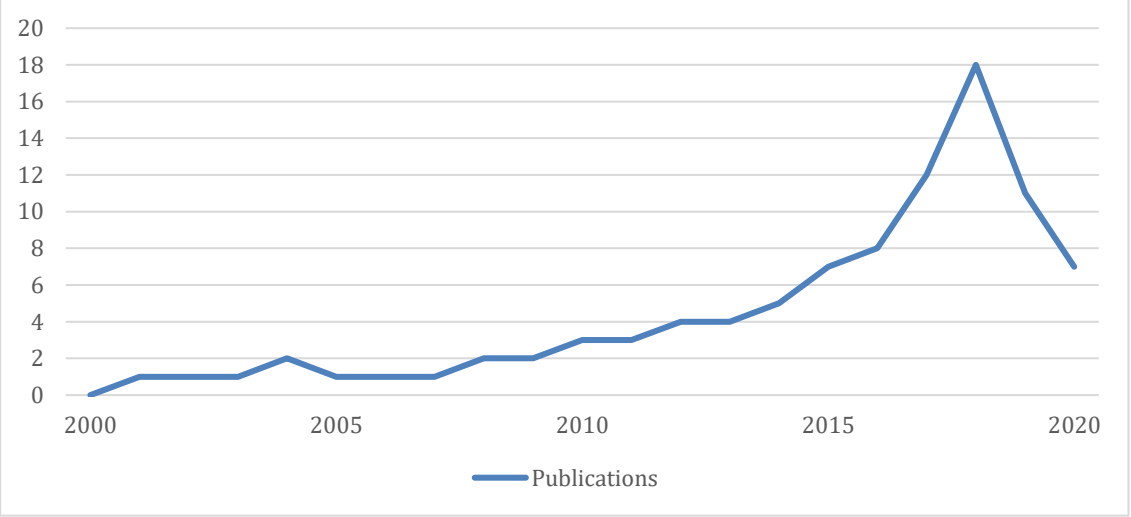

Figure 3.2. Publications time range

3.6. Factor Extraction and Mapping of Studies

To answer the Research Question 1, Table 3.3 has been presented. This table contains 10 summarized factors that obtained from 90 relevant articles and expert opinions. Three experts have been interviewed to find out their opinions' about factors. All three experts have considerable aeronautical software development experience. First expert is a senior technical manager who has been dealing with aeronautical software for nearly 20 years

and DO-200A software for 5 years. The 2nd expert is a senior software engineer with nearly 5 years of aeronautical software background, but has been involved in software development for 20 years. The third expert is an expert who has been working as a project manager for 1 year after about 20 years of aviation software testing expertise.

Table 3.3. Factor list and experts' opinions

Factor No	Factor Name	Expert 1 Opinion	Expert 2 Opinion	Expert 3 Opinion	Number of Studies
F01	Lack of Communication	+	+	+	43
F02	Concept Complexity	+	+	+	28
F03	Lack of Training/Learning	+	+	+	21
F04	Gaps in Validation/Verification	-	+	+	6
F05	Independent Controls/Audits	-	+	+	11
F06	Tool Qualification	-	+	-	7
F07	Understandability	+	-	+	25
F08	Ignored Points in Validation/Verification	-	+	+	6
F09	Uncertainty of the Standard	+	+	+	17
F10	Lack of Management	+	+	+	33

+ : The expert judges that this factor will affect organization's adoption to the DO-200A standard.

It is necessary to be able to understand in order to analyze the obtained factors. Interpretations and inferences for the obtained factors are as follows:

- F01: When tasks are not clear, a lack of communication occurs as a result of a lack of leadership, diverse work culture, demoralized employees, personal problems, and employee difficulties.
- F02: When project plan and objectives are not clear, poor communication with stakeholders and partners, and concept complexity reveals.
- F03: Whether there is no training to learn standard, concept etc., employees may be impacted and incomplete to do tasks.
- F04: When project plan and objectives are not clear, there may be parts missing from validation/verification process.
- F05: If independent persons or institutions do not carry out the audits, there may be situations that may be overlooked and being aware of this may push employees to neglect.
- F06: Lack of a tool that is intended to be used to automate the verification, validation and audit processes causes both the workload and the motivation of the employees due to this additional burden.
- F07: In fact, if the communication channels are not clear, if there are unclear situations, there are issues such as understanding how to apply the standard and how to ensure compliance with the lack of training and information.
- F08: Along with negative situations such as lack of communication and management, there may be an increase in overlooked situations.
- F09: The first or new implementation of the standard affects compliance with the standard, together with the lack of field knowledge, lack of experience and even fear of the new.
- F10: The inexperience of those who manage the project, combined with the lack of communication skills, can cause serious problems.

The brief overview about summarized 10 factors obtained from 90 relevant articles and expert opinions are as follows:

- As a result of Systematic Mapping Study, factors in different areas such as lack of management, lack of communication and concept complexity have been identified. It has been determined that a significant part of the factors affecting the compliance of software organizations with the standards regarding software development is related to managerial issues rather than technical difficulties.

- In the eyes of the standard, technical issues on the novelty, uncertainty, and training of the standard have also been heavily addressed by experts and articles.
- The problem of lack of communication, which is the most common factor in research, is the basis of many factors, the sooner it is resolved the better. If it is not resolved in time, it would be like not solving a mistake in the planning stage, but emerging and trying to fix it after the test stage.
- It has been observed that concept complexity, understandability, lack of communication are factors that affect each other quite a lot.
- In the interviews with the experts, it was stated that developers and testers may be afraid in projects where the standard is applied for the first time because of the uncertainty of the Standard.
- The paper of Cheng, J. et al [27] , scalability, managing change, complexity of the system, requiring special skills, too “Flexible”, uncertainty, incomplete information factors extracted. It is seen that the factors obtained in the study have come to the fore in many studies such as this study.
- As in their work the papers [11, 18, 19], managerial problems also pose an important problem in the implementation of standards. The paper [18] concludes with suggestions and guidelines for advances in software quality management concepts, such as the ISO 9000 family, CMM, BOOTSTRAP and the emerging SPICE standard. This study has been also examined to get different perspectives and suggestions. This article [19] provides a comprehensive overview of the important civil aviation standard for airborne software (RTCA / DO-178B, 1992), as well as a comparative summary of a selection of other software engineering standards from different industrial sectors. In addition to comparing a standard in the aviation sector with other standards, it has been one of the exemplary publications because it sheds light on the sector and made various suggestions.

4. METHODOLOGY

This chapter represents the methodology of the study. This study was carried out in three steps as depicted in Figure 6. These steps are research design; survey process, analysis and results. In this research, the mixed method research design was employed, and the data collection and analysis of the quantitative and qualitative data were carried out.

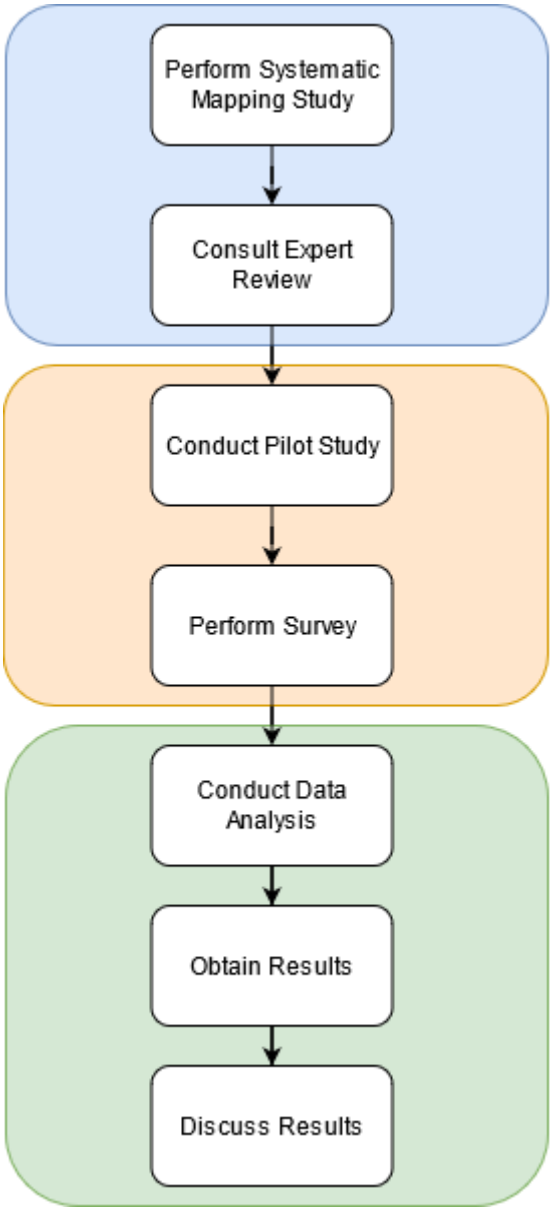

Figure 4.1. Design of the study

4.1. Research Design

First, theoretical model have been developed. Our theoretical model includes determining what type of research method will be used and what kind of study will be applied afterwards that will determine the factors affecting compliance. The research method was determined according to the theoretical model. In fact, our research model includes SMS. These details have been specified in section 3. After that, the questionnaire implemented. Next section, the questionnaire has been presented. The explanations of the steps in Figure 4.1. are as follows:

Perform Systematic Mapping Study

Systematic Mapping Study has been used to determine the scope in the certain field, and to combine the results in answering the research questions more specifically to structure the results by a high level analysis.

Consult Expert Review

For the factors obtained by SMS, experts were consulted to reach a common consensus about the factors that might affect compliance with the DO-200A Standard.

Conduct Pilot Study

A pilot questionnaire was prepared according to the obtained factors and applied to a few people experienced in DO-200A, and they were expected to give feedback on the questions. The questionnaire has been finalized according to the feedback obtained.

Perform Survey

The questionnaire instrument you will see in Appendix B was completed by 34 people experienced in DO-200A. Detailed information is available in section 4.2.

Conduct Data Analysis

It indicates the analysis part of the data obtained by digitizing the answers to the questionnaire. For the analysis, the data analysis tool called SPSS was used.

Obtain Results

Descriptive statistics and weighted arithmetic mean calculations made in SPSS tool were obtained and discussed.

Integrate Results

Descriptive statistics and weighted arithmetic mean calculations were combined as a result and some suggestions were made.

4.2. Survey (Questionnaire)

Surveys are an essential tool for software engineering research and should be promoted to gather information about what software engineers actually do, and to evaluate prescribed practices, methods, tools and standards [29].

The survey represents a major step towards developing a better understanding of determination of factors that affect the adoption of DO-200A, and its results can be useful both for academia and for industry. Researchers can identify gaps in the current state of the art that could be addressed in the future, as well as aspects in the state of the practice that might be improved by means of new research efforts. While further data collection would be beneficial for drawing stronger conclusions from our findings, the systematic procedure applied for conducting the survey combined with diversity of the respondents make us confident about the usefulness and representativeness of the results. In addition to these positive situations, the fact that there are very few participants experienced in DO-200A stands out as one of the threats of the survey that may pose a risk.

Besides all these situations, a disadvantage of the questionnaire survey method is that the respondents are provided with a list of possible factors and asked to select from that list. This tends to preempt the factorsinvestigated and to limit them to those reported in existing studies – respondents only focus on thefactors provided in the list. It is also possible that the respondents may misinterpret the factors provided in the questionnaire.

4.2.1. Survey Structure

The questionnaire consists of 3 parts, starting with the receipt of the email information in order to prevent the participation of the same participant, and continue with the part where the demographic information is requested, and we inquire about the technical information, which is our main data. In demographic questions, considering that each user will have a different level and feature, open-ended questions or non-likert-scale questions were asked. In the last part, 5 Likert scale questions were used. Google forms application was used for the survey. The survey instrument used can be seen in Appendix B. The survey study was exported as files with .xslx extension and sent for analysis. For the analysis, the data analysis tool called SPSS Statistics V26 was used. It is mandatory to answer all questions and participants must be experienced with DO-200A.

4.2.2. Survey Process

First of all, experts and sector-experienced people were consulted continuously during the preparation of the questionnaire. The main purpose here has been to make a continuous improvement. In order to create the questionnaire, factors were produced according to SMS results, and a pool of questions that could serve as an example was created with these factors. These questions were subjected to expert review first, and then, questions were asked to a few people who had experience in the DO-200A Standard, blended with expert opinions. Then, a pilot survey was created and applied to a few people who were also experienced in the DO-200A Standard. The study was finalized with the feedback from this survey. The survey was left open for 3 months between 2020 December and 2021 March. In order to reach more people, it was shared on social media (Linkedin, Whatsapp, etc.), mail groups, and course pages. However, participation in the survey was low due to the ability to have experience in the DO-200A Standard, which is a requirement. In order for the answers to have a numerical meaning, it was printed out as an excel file and transformed into meaningful data as much as possible in the analysis part with the next step, statistical methods.

5. DISCUSSION

This chapter presents results of the study. The results of each phase are given below separately. Phase 1 starts with the demographic information of the participants and continues with general properties of the data. After that, in the Phase 2, the technical questions created according to the 5-point Likert scale and the analysis of the answers given are discussed. Finally, all results of the technical questions and factor mapped weighted arithmetic mean are integrated.

5.1. Phase 1: Demografics

Table 5.1. Frequencies of roles (%)

Role Name	Frequency	Percent
Software Engineer/Specialist/Manager	18	52.9
Quality Engineer/Specialist/Manager	2	5.9
Team Leader	1	2.9
Project Manager	6	17.6
Test Engineer/Specialist/Analyst	2	5.9
System Engineer/Specialist/Manager	2	5.9
Verification/Process/Certification Engineer/Expert/Manager	3	8.8
Total	34	100

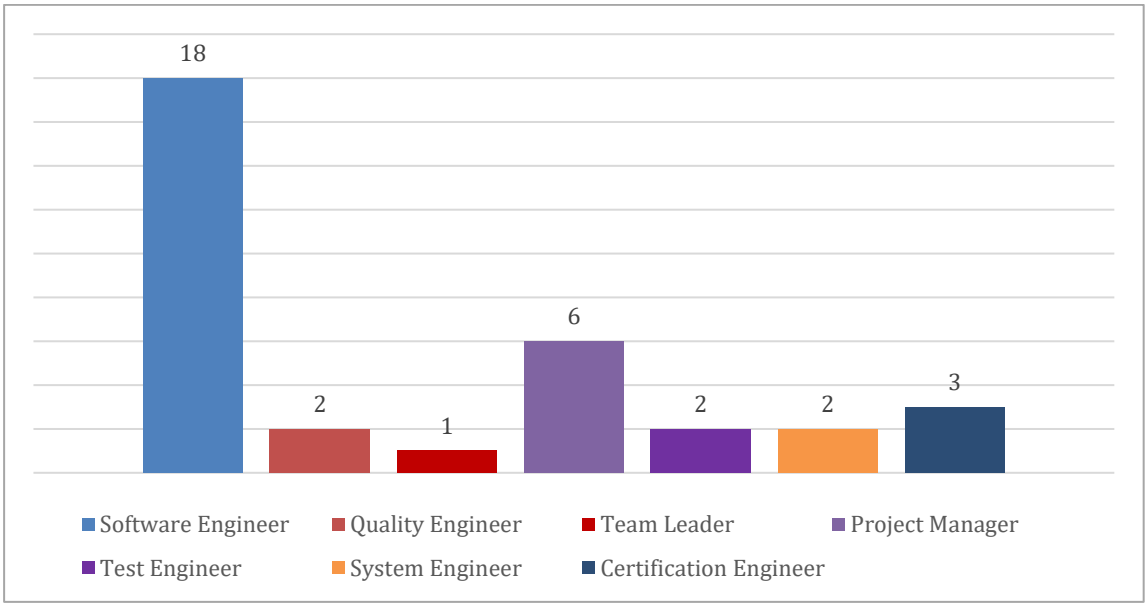

Figure 5.1. Bar chart of the distribution of roles

The highest participation was from the role of Software Engineer / Specialist / Manager with 18 people (52.9%). The least participation was from the Team Leader role with 1 person (2.9%). This distribution was an expected result. Although participation is less, it has been observed that there is diversity. This diversity creates a positive contribution in terms of giving more accurate results of the survey, thanks to the participants working in different roles, answering the surveys with different perspectives in line with their areas of expertise.

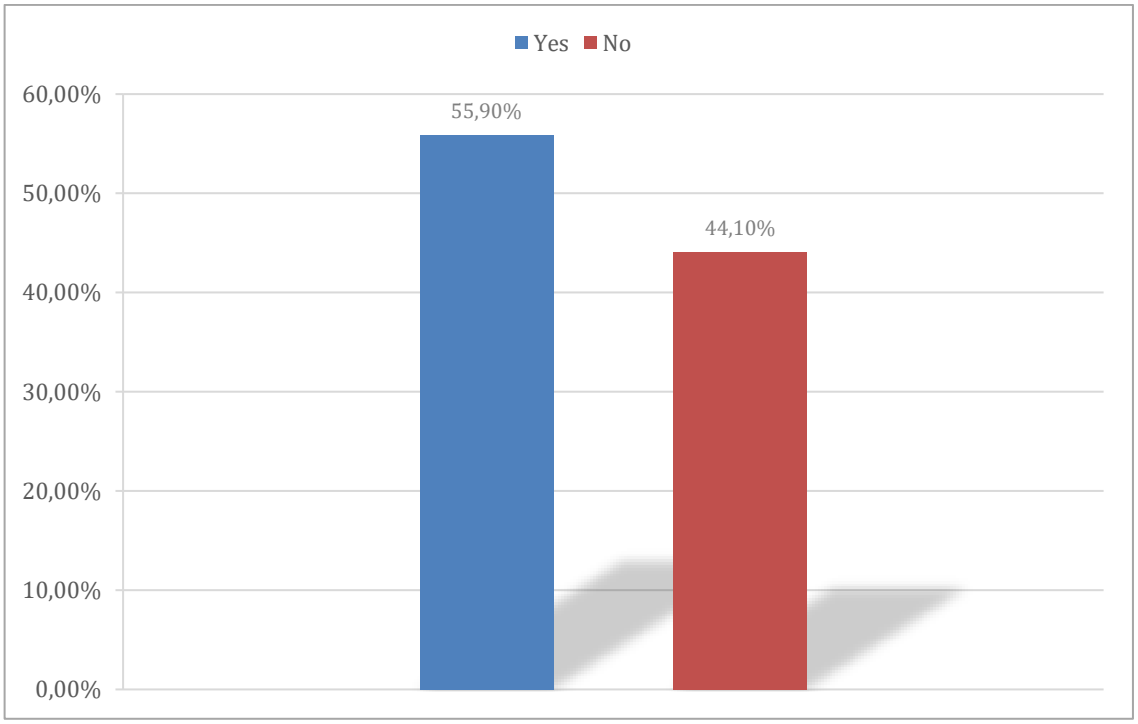

Figure 5.2. Bar chart on whether to train or not

It is observed that 55.9% of the participants (19 people) received training in the DO-200A Standard. Here, the conclusion that these trainings were given by experienced people for the institution was emphasized in the expert opinions. The people mentioned as experts here are the people consulted in the process of determining the factors that form the basis of the survey questions.

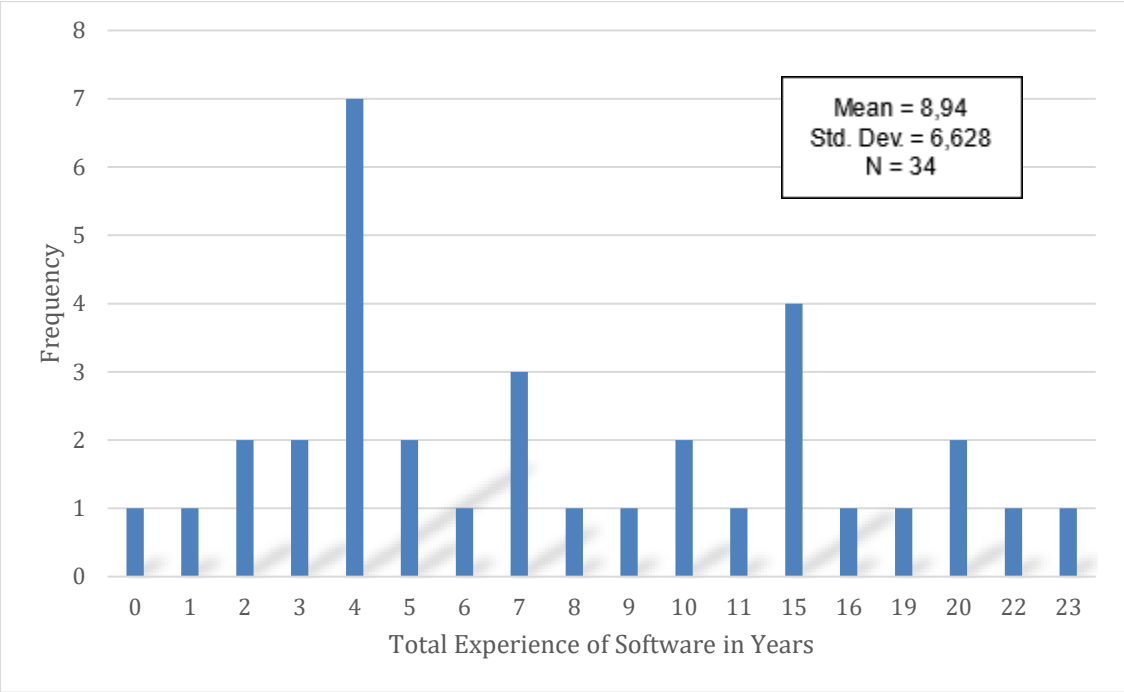

Figure 5.3 Total Experience of Software

In terms of software project experience, it was observed that there was an accumulation of 4 years and 15 years of experience of the participants. In addition, the presence of participants with different years of experience in the range of 0 - 23 years is also positive in terms of diversity. It is seen in the following sections that the diversity in this experience also enables different contributions.

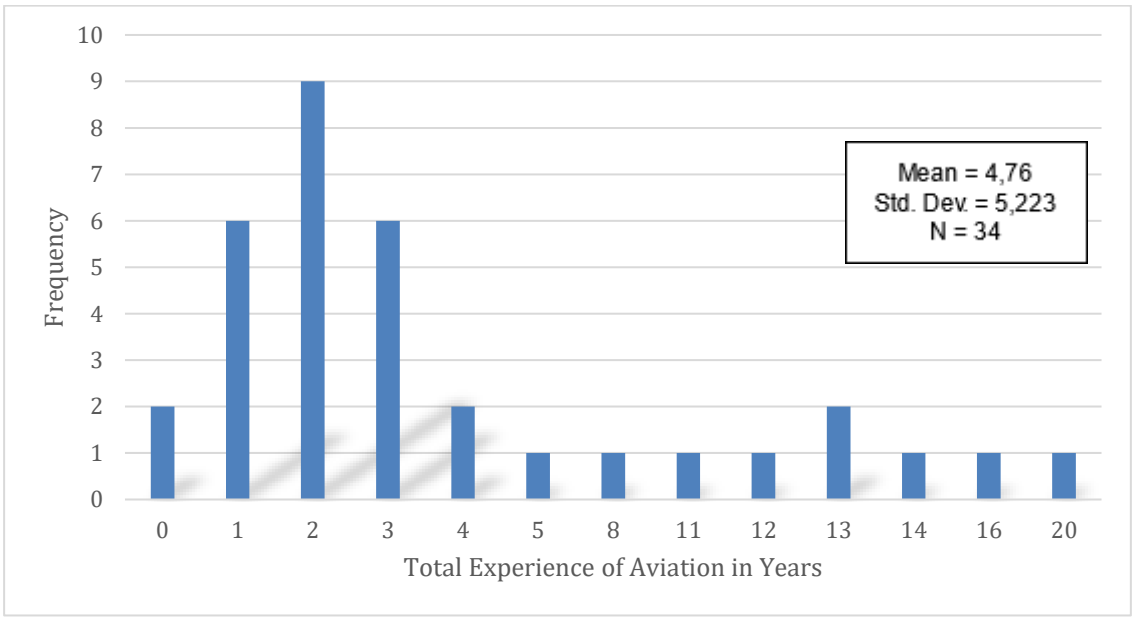

Figure 5.4. Total Experience of Aviation

In terms of aviation software project experience, it has been observed that the participants have 2-3 years of experience more than half of the participants. In addition, it is important

to have participants with high experience in aviation software in terms of evaluating the survey. It is seen that experience in aviation software is less, and this is considered to be an important parameter in the process of adapting to the DO-200A Standard.

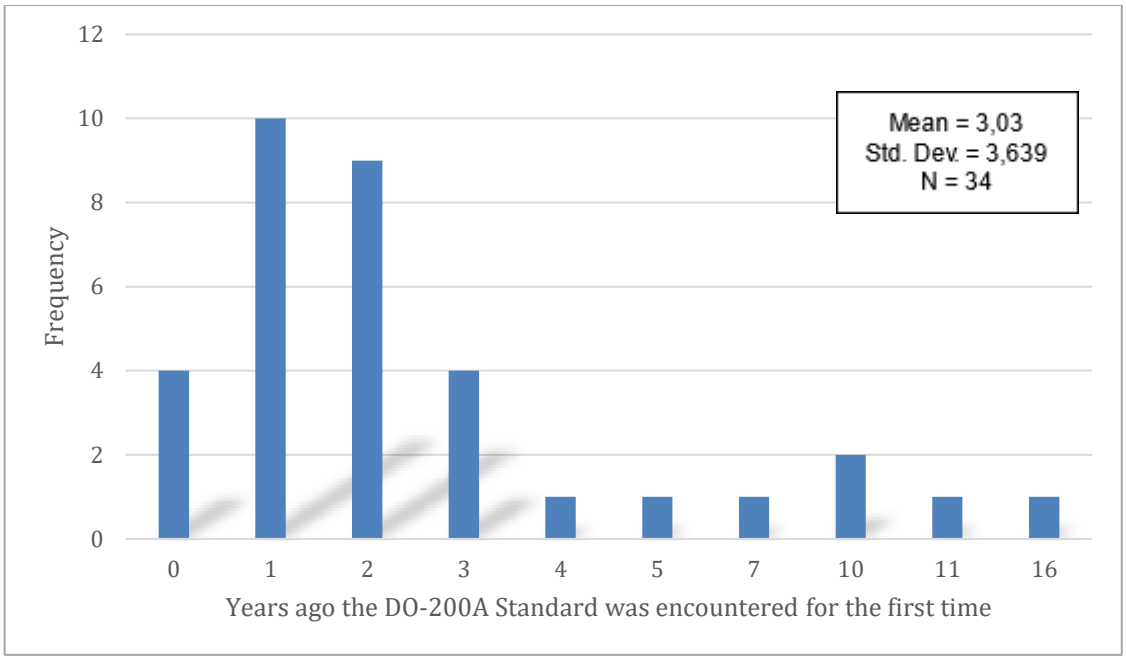

Figure 5.5. First meeting the DO-200A Standard

Considering the average of all participants, the time to first meet with DO-200A Standard is 3.03 years. Based on this value obtained, it can be concluded that the DO-200A Standard has just started to be used or is needed.

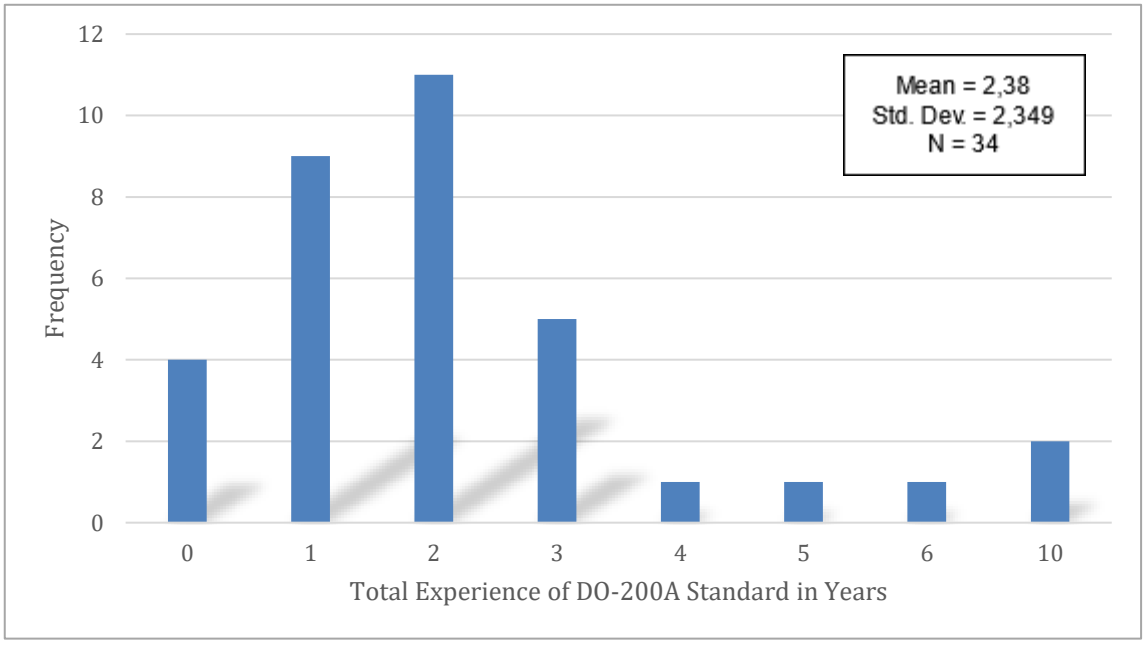

Figure 5.6. Total experience with DO-200A Standard

The first time to meet with the DO-200A Standard and the total working time in the projects that are trying to comply with the DO-200A Standard will be evaluated together. Here, it was seen that although the acquaintance of the participants with DO-200A was older, the experience was not that much. In addition, the lack of experience, which is one of the most important results we have obtained from our study, stands out here.

5.2. Phase 2: Technical Questions

In this section, descriptive analyzes such as mean and frequency of the responses given by the participants to the questionnaire will be explained and evaluated. Likert 5 Scale was used in this questionnaire with 34 participants. Accordingly, participants were expected to choose one of the options with numerical equivalents as follows:

- 1.0 = Does not affect
- 2.0 = Little affects
- 3.0 = Moderate affects
- 4.0 = High affects
- 5.0 = Critical affects

The mean values in the questions were obtained from the numerical equivalents of the answers given. For each survey question, factor question mapping was made with factors that obtained as a result of the Systematic Mapping Study we conducted in December 2020, were selected specifically for the DO-200A Standard, and the questions were analyzed and interpreted according to these factors.

Question - 1

To what extent does knowing the purpose of use of DO-200A Standard in projects affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 4.03 and the standard deviation is 0.834. In this question, n = 28 of the 34 participants who participated in the study think that knowing the intended use of the DO-200A Standard will affect the compliance with this standard or critically. According to all this information, the participants think that knowing what this standard will be used for and if the necessary actions are done, there will be less problems, errors and delays. We found out in our previous research that situations such as lack of communication and management underlie

this. In other words, the basic problem in this question can be solved if experienced and knowledgeable personnel can convey this knowledge and experience through open communication channels and managers manage the existing processes well.

Table 5.2. Distribution of experience with DO-200A according to the answers given

To what extent does knowing the purpose of use of DO-200A Standard in projects affect compliance with DO-200A Standard?	How long did you work for the project (s) trying to comply with the DO-200A Standard?
Doesn't affect	0.00
Moderate effects	1.80
High impact	1.89
Critical effects	4.00
Total	2.38

According to another table we have obtained, as the experience of DO-200A increases, the idea that knowing the purpose of the standard will affect compliance with the standard becomes clear.

Question - 2

To what extent does knowing the purpose of use of DO-178C Standard affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.44 and the standard deviation is 0.991. In this question, n = 16 of the 34 participants who participated in the study think that knowing the purpose of use of the DO-178C Standard will greatly affect or critically affect compliance with the DO-200A Standard. According to all this information, the participants think that the DO-200A Standard can easily be understood if the more inclusive DO-178C Standard is known for what it will be used for. The reason for this was the lack of training in our article, which we published. In other words, with a quality and efficient DO-200A training that can be obtained, such problems will be prevented by clarifying the situations such as what the standard contains and what it offers.

Table 5.3. Distribution of experience with DO-200A according to the answers given

To what extent does knowing the purpose of use of DO-178C Standard affect compliance with DO-200A Standard?	How long did you work for the project (s) trying to comply with the DO-200A Standard?
Doesn't affect	0.00
Little effects	2.75
Moderate effects	2.15
High impact	1.64
Critical effects	4.80
Total	2.38

According to another table we have obtained, it is observed that as the experience of DO-200A increases, the idea that knowing the purpose of the DO-178C Standard will affect compliance with the DO-200A Standard becomes evident.

Question - 3

To what extent does providing a supportive infrastructure in applying / testing / evaluating / configuring the DO-200A Standard affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.91 and the standard deviation is 0.793. In this question, n = 27 of the 34 participants who participated in the research think that providing a supportive infrastructure will affect compliance with this standard or critically. According to all this information, he thinks that a tool that automates the processes in the implementation of this standard, using the infrastructure will help the processes to be carried out more efficiently and smoothly. In our article, we found that the basis for this was the lack of management or tool qualification that could not ensure the use of such an infrastructure.

Question - 4

To what extent does the involvement of persons who have previously gained experience with the DO-200A Standard in the preparation of the procedures to be applied in the verification / validation of the DO-200A standard affect the compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.88 and the standard deviation is 0.808. In this question, n = 26 of the 34 participants who participated in the

study think that utilizing experienced personnel for verification and validation processes will affect the compliance with this standard or critically. According to all this information; The participants think that the verification and validation processes, which are helped by experienced personnel in the implementation of this standard and convey their knowledge and experience, will involve less problems and errors, and experience less delays. In our article, we found that the problem here lies in insufficient verification and validation processes and the presence of personnel who lack experience in such processes. In other words, with the transfer of this knowledge and experience by the experienced and knowledgeable staff, the gap of the personnel who lack experience can be closed and the insufficient verification and validation situations can be prevented.

Question - 5

In the implementation of the DO-200A standard, how much does it affect compliance with the DO-200A Standard by receiving services or consultancy by independent institutions that provide Compliance Verification Engineering and Consultancy services in the verification / validation and compliance processes?

It is seen that the average of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.47 and the standard deviation is 0.896. In this question, n = 16 of the 34 participants who participated in the study think that utilizing experienced personnel for verification and validation processes will affect compliance with this standard or critically. According to all this information; The participants think that the verification and validation processes, which are helped by experienced personnel in the implementation of this standard and convey their knowledge and experience, will involve less problems and errors, and experience less delays. Here, we have found in our previous research that insufficient verification and validation processes and the presence of personnel who lack experience in such processes lie. In other words, with the transfer of this knowledge and experience by the experienced and knowledgeable staff, the gap of the personnel who lack experience can be closed and the insufficient verification and validation situations can be prevented. In addition, it can be concluded that it is important to carry out audit activities by independent mechanisms, and these activities will facilitate and accelerate compliance.

Question - 6

In the implementation of DO-200A Standard, to what extent does the use of tool (s) that automate all steps in the verification / validation and compliance processes in an inclusive manner affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.71 and the standard deviation is 0.906. In this question, n = 21 of the 34 participants who participated in the study think that utilizing experienced personnel for verification and validation processes will affect the compliance with this standard very or critically. According to all this information; Participants believe that the use of a tool that automates the processes in the implementation of this standard, the infrastructure, will help the processes to be carried out more efficiently and smoothly. The basis of this is that efforts to comply with this standard are just starting in aviation projects in our country, and therefore, manual implementation efforts at the first stage in such new processes. It turns out that an infrastructure or tool support that automates these manual processes is required to make the transactions fast and error-free.

Table 5.4. Distribution of experience with DO-200A according to the answers given

In the implementation of the DO-200A standard, to what extent does the use of tool (s) that automate all steps in the verification / validation and compliance processes in an inclusive manner affect compliance with the DO-200A Standard?	How long did you work for the project (s) trying to comply with DO-200A Standard?
Doesn't affect	0.00
Little effects	10.00
Moderate effects	2.64
High impact	1.6
Critical effects	3.00
Total	2.38

According to another table we have obtained, it was observed that as the experience of DO-200A increases, the idea that the use of a tool that automates the processes in the implementation of the standard will not affect the compliance with the standard becomes more evident.

Question - 7

In the process of compliance with the DO-200A Standard, to what extent does the confusion of application integrator and data generator concepts affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.65 and the standard deviation is 0.884. In this question, n = 20 of the 34 participants who participated in the study think that such concept complexity situations that cause the roles of stakeholders

such as application integrators and data producers to be confused will affect the compliance with this standard or critically. According to all this information; it was observed that the participants thought that the concepts were confused in the implementation of this standard and that this confusion caused the work to be done to be problematic. In other words, with a qualified and efficient DO-200A training that can be obtained, such problems can be prevented by the experienced personnel who play an active role in clarifying the concepts as in many subjects.

Question - 8

To what extent do the thinking that the DO-200A Standard and the DO-178C Standard envisage the same processes and do the same works, the confusion of the concepts mentioned by the standards affect the compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.41 and the standard deviation is 0.892. In this question, n = 16 of the 34 participants participating in the research, as in the previous question, the content, applications of DO-200A and DO-178C Standards, etc. They think that the confusion of certain concepts will either greatly affect or critically affect compliance with this standard. According to this; Participants were observed that the concepts of these two standards, which are related to each other, were confused in the implementation of this standard, and they thought that this confusion caused the applications to be problematic in the validation, validation and compliance processes. In other words, with a qualified and efficient DO-200A training that can be obtained, such problems can be prevented by the experienced personnel transferring their experiences about which process belongs to which standard.

Question - 9

To what extent does making a distinction between the data characteristics of the DO-200A standard (Accuracy, Resolution, Assurance Level, Traceability, Timeliness, Completeness, Format) according to their importance, that is, paying more attention and importance to providing the characteristics considered important, affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.59 and the standard deviation is 1.048. In this question, n = 20 of the 34 participants who participated in the study stated that not knowing what the basic building blocks of the DO-200A Standard

are, taking an important distinction here and the emergence of development, verification and validation problems due to this will affect compliance with this standard or critically. It was observed that he thought it would affect. According to this; Participants think that there is a problem that starts from the basics because of the lack of experience, lack of training, and the inability of those who have knowledge on the subject to convey this to what the building blocks of this standard are. In other words, with a qualified and efficient DO-200A training that can be obtained, such problems can be avoided after the experienced personnel clearly convey their experience.

Question - 10

To what extent do the training (s) received in order to effectively implement the DO-200A standard affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.62 and the standard deviation is 0.853. In this question, n = 18 of the 34 participants who participated in the study stated that not knowing what the basic building blocks of the DO-200A Standard are, taking an important distinction here and the emergence of development, verification and validation problems due to this will affect compliance with this standard or critically. According to this; it can be deduced that the lack of knowledge that arose because the participants did not receive a training that includes what the standard aims at, important points, and examples to be able to develop in accordance with this standard can lead to the idea of being lost. In other words, with a quality and efficient DO-200A training that can be obtained, it is possible for the implementing personnel to have basic knowledge about the standard and to contribute to the adaptation to the process with the knowledge.

Question - 11

To what extent does understanding the DO-200A standard in all aspects and effectively affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.88 and the standard deviation is 0.946. In this question, n = 24 of the 34 participants who participated in the study stated that not knowing what the basic building blocks of the DO-200A Standard are, taking an important distinction here and the emergence of development, verification and validation problems due to this will affect compliance with this standard or critically. It was observed that he thought it would affect. According to this; It can be thought that

the participants should receive a training so that the people who will take an active role in the harmonization process with the standard are basically informed. In other words, with a quality and efficient DO-200A training that can be obtained, the problems that may arise when the practitioners have at least an idea about the subject and then their mastery of the processes can be prevented.

Question - 12

How does the necessary coordination and communication with stakeholders in the implementation of the DO-200A standard, verification / validation and compliance processes affect compliance with the DO-200A Standard?

It is seen that the mean of the answers is 3.79 and the standard deviation is 0.914, thanks to the mean and standard deviation, which are the values we have reached through the frequency table. In this question, n = 23 out of 34 participants who participated in the research, it was stated that not knowing what the basic building blocks of the DO-200A Standard are, taking an important distinction here and the emergence of development, verification and validation problems due to this will affect compliance with this standard or critically. It was observed that he thought it would affect. According to this; it can be thought that situations such as ensuring the communication and coordination of the participants with the stakeholders in the process of compliance with the standard, and the provision of such a channel, will ensure that the requirements of the standard are fulfilled. So; For example, thanks to the existence of an open communication channel among the developers where a staff specialized in this field can convey their experiences, the implementation of the standard can be achieved in a short time when there is a problem in the adaptation processes, and the problems can be prevented before they arise.

Question - 13

To what extent does the existence of DO-200B or other software quality standards claiming to meet the same requirements instead of the DO-200A standard, and not being able to use them affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 2.82 and the standard deviation is 1.267. In this question, n = 10 of the 34 participants who participated in the study stated that not knowing what the basic building blocks of the DO-200A Standard are, taking an important distinction here and the emergence of development, verification and validation problems due to this will affect the compliance with this standard or

critically. It was observed that he thought it would affect. According to this; It can be deduced that the participants think that choosing a more up-to-date version of the DO-200A Standard such as DO-200B would not make a big difference.

Question - 14

To what extent do activities such as integration of 3rd party software to make an existing system compatible with DO-200A affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.38 and the standard deviation is 0.985. In this question, n = 17 of the 34 participants who participated in the research think that activities such as 3rd party software integration to make the existing system comply with the DO-200A standard will affect the compliance with the standard or critically. According to this; Participants may consider whether such needs will be required or not, and the importance and meaning of supportive software that will prevent problems from occurring, thanks to the easy understanding of the DO-200A Standard.

Question - 15

To what extent does the understandability of the DO-200A standard affect the compliance with the DO-200A Standard in the project that must comply with the standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.79 and the standard deviation is 0.978. In this question, n = 23 of the 34 participants who participated in the study think that the understandability of this standard will either affect the compliance with the standard or critically. In other words, it is concluded that the legibility of the standard, its understandability by reading, and its clarity will facilitate compliance with the standard.

Question - 16

It is not clear which roles and responsibilities will be in the process of compliance with the DO-200A standard; for example, taking all responsibility on the software development team, etc. To what extent do situations affect compliance with DO-200A Standard?

It is seen that the average of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.91 and

the standard deviation is 0.965. In this question, n = 26 of the 34 participants who participated in the study think that the uncertainty of the roles' responsibilities in the process of compliance with the DO-200A standard will affect or critically affect the compliance with the standard. According to this; The participants think that DO-200A Standard can easily be understood if the DO-200A Standard is poorly understandable or if the lack of training is known for what it will be used for. The reason for this was the lack of training in our published article.

Question - 17

To what extent does the presence of gaps, deficiencies or overlooked points in the verification and validation of the DO-200A standard affect the compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.97 and the standard deviation is 0.937. In this question, n = 26 of the 34 participants who participated in the study think that the presence of some deficiencies or overlooked points in the validation and validation processes of the DO-200A standard will greatly affect or critically affect the compliance with the standard. Here, we have found in our previous research that insufficient verification and validation processes and the presence of personnel who lack experience in such processes lie. In other words, with the transfer of this knowledge and experience by the experienced and knowledgeable staff, the gap of the personnel who lack experience can be closed and inadequate verification and validation situations can be prevented.

Question - 18

To what extent does updating process assets in the verification and validation of DO-200A standard affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.41 and the standard deviation is 0.937. In this question, n = 17 of the 34 participants who participated in the study think that updating process assets in case of need in the validation and validation processes of the DO-200A standard will affect the compliance with the standard or critically. Here, in our previous research, we have found that there are insufficient verification and validation processes and administrative problems that cannot take any steps to eliminate the problems in the processes. In other words, for the solution of

problematic, disrupted verification and validation processes, there should be a management staff who can make a decision that can change the process assets to provide a solution from A to Z when necessary.

Question - 19

Implementation / verification of DO-200A standard etc. To what extent does making any improvement suggestions for the defects and deficiencies seen in the processes, and then addressing this proposal affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.47 and the standard deviation is 0.896. In this question, n = 19 out of 34 participants who participated in the research, it was stated that conducting studies to improve the deficiencies in the validation and validation processes of the DO-200A standard, making a suggestion on this issue, then addressing this and taking the necessary steps will greatly affect the compliance with the standard or are critical. Here, in our previous research, we have found out that there are managerial problems that cannot take any steps to solve the problems in the processes. In other words, it is necessary to eliminate the lack of management that can take the necessary steps to solve the problematic, failing verification and validation processes.

Question - 20

Verification, validation etc. of DO-200A standard. To what extent does audits by independent persons, institutions or authorities affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.88 and the standard deviation is 0.808. In this question, n = 26 of the 34 participants who participated in the research think that the audits of the verification and validation processes by independent persons or institutions will affect compliance very much or critically. According to this; Participants have an objective review of what is wrong and what is right, thanks to the independent institutions performing these works during the audit stages of the compliance of this standard. Thanks to these objective opinions, it can be thought that more permanent and accelerating solutions may have been implemented for the harmonization of the process.

Table 5.5. Distribution of experience with DO-200A according to the answers given

Verification, validation etc. of DO-200A standard. To what extent does audits by independent persons, institutions or authorities affect compliance with DO-200A Standard?	How long did you work for the project (s) trying to comply with DO-200A sStandard?
Doesn't affect	0.00
Moderate effects	1.71
High impact	2.00
Critically effects	4.83
Total	2.38

According to another table we obtained, it was observed that as the experience of DO-200A increases, the idea that using independent institutions or individuals to audit the standard will affect compliance with the standard becomes more evident.

Question - 21

Verification, validation, compliance etc. in processes. To what extent does the lack of clarity on how the inspections will be conducted affect compliance with the DO-200A Standard?

It is seen that the average of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 4.03 and the standard deviation is 0.834. In this question, n = 28 of the 34 participants who participated in the study think that the lack of clarity about the verification, validation, compliance processes and the audits of these processes will affect the compliance with the standard or critically. According to this; It can be deduced that the participants will think that uncertainty negatively affects compliance in the application of this standard, especially in the verification and validation activities, causing an increase in error rate or slowness. In other words, with a qualified and efficient DO-200A training that can be obtained, such problems can be prevented by the experienced personnel playing an active role in clarifying the concepts and processes, as in many subjects.

Question - 22

The implementation of DO-200A Stadandard in aviation projects in the context of an organization, lack of validation and audit experience, etc. to what extent do situations affect compliance with DO-200A Standard?

It is seen that the average of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.71 and the standard deviation is 0.834. In this question, n = 21 of the 34 participants who

participated in the research think that the unclear how to perform the verification, validation, compliance processes and the audits of these processes will affect the compliance with the standard or critically. According to this; In the implementation of this standard, it can be deduced that the participants think that the verification and validation processes that have organizational experience and consequently experienced personnel help, transfer their knowledge and experience will involve less problems and errors and experience less delays. In other words, it will be difficult for an institution with a lack of experience to produce a product that complies with the standard. In order to prevent problems caused by lack of experience, measures such as various consultancy services, provision of experienced personnel can be taken.

Question - 23

When the project plans and objectives are not clear in terms of DO-200A Standard, how does the emergence of conceptual confusion due to poor communication with stakeholders affect compliance with the DO-200A Standard?

It is seen that the mean of the answers is 3.88 and the standard deviation is 0.808, thanks to the mean and standard deviation, which are the values we have reached through the frequency table. In this question, n = 21 of the 34 participants participating in the research think that the emergence of situations such as concept complexity due to the uncertainty of the steps to be applied in projects that need to comply with the standard and poor communication with stakeholders will affect the compliance with the standard or critically. According to this; The participants know what this standard will be used for and think that if the necessary actions are done, there will be less problems, errors, and delays. We found out in our previous research that situations such as lack of communication and management underlie this. In other words, the basic problem in this question can be solved if experienced and knowledgeable personnel can convey this knowledge and experience through open communication channels and managers manage the existing processes well.

Question - 24

To what extent does benefiting from current technologies in projects where DO-200A Standard is used affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.24 and the standard deviation is 1.017. In this question, n = 14 of the 34 participants who participated in the study think that the emergence of situations such as concept complexity due to the

uncertainty of the steps to be applied in projects that need to comply with the standard and poor communication with the stakeholders will affect the compliance with the standard or critically. According to this; The participants know what this standard will be used for and think that if the necessary actions are done, there will be less problems, errors, and delays. We found out in our previous research that situations such as lack of communication and management underlie this. In other words, the basic problem in this question can be solved if experienced and knowledgeable personnel can convey this knowledge and experience through open communication channels and managers manage the existing processes well.

Table 5.6. Distribution of experience with DO-200A according to the answers given

To what extent does benefiting from current technologies in projects where DO-200A Standard is used affect compliance with DO-200A Standard?	How long did you work for the project (s) trying to comply with DO-200A Standard?
Doesn't affect	2.00
Little effects	4.00
Moderate effects	2.15
High impacts	2.36
Critical effects	1.00
Total	2.38

According to another table we obtained, it was observed that as the experience of DO-200A increases, the idea that using up-to-date technologies in the implementation of the standard will not affect the compliance with the standard becomes evident.

Question - 25

In the implementation, compliance, etc. of the DO-200A Standard. To what extent does existence of managerial problems in processes affect compliance with DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.74 and the standard deviation is 0.790. In this question, n = 18 of the 34 participants who participated in the study think that the existence of administrative problems in the implementation of the standard and the compliance processes will affect the compliance with the standard or critically. According to this; The participants know what this standard will be used for and think that if the necessary actions are done, there will be less problems, errors, and

delays. We found out in our previous research that situations such as lack of communication and management underlie this. In other words, the basic problem in this question can be solved if experienced and knowledgeable personnel can convey this knowledge and experience through open communication channels and managers manage the existing processes well.

Question - 26

To what extent does knowing the usage areas / purposes of the DO-200A Standard regardless of the projects that are trying to comply with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.41 and the standard deviation is 0.892. In this question, n = 18 of the 34 participants who participated in the study think that the knowledge of the usage areas / purposes, regardless of the projects that need to comply with the DO-200A Standard, will affect the compliance with this standard or critically. Here, it can be deduced that the personnel applying this standard in accordance with defense industry projects and trying to comply with these projects have other usage or application areas / purposes other than the perspective of these projects, and they know them. Regardless of out-of-perspective projects, what kind of applications will be can be provided by having sufficient knowledge about the standard. In other words, with a quality and efficient DO-200A training that can be obtained, it is possible for the implementing personnel to have basic knowledge about the standard and to contribute to the adaptation to the process in uses other than defense industry projects.

Question - 27

To what extent do the busy working times in the working environment affect compliance with the DO-200A Standard?

It is seen that the average of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.38 and the standard deviation is 0.888. In this question, n = 15 of the 34 participants participating in the research, as it can be understood from the average value, think that the constraints that arise due to the high degree of confidentiality in the projects will affect the compliance with the standard or critically. Here, it can be deduced that the existing restrictions are not an issue that will affect compliance due to the degree of confidentiality.

Question - 28

To what extent do the restrictions arising due to the high degree of confidentiality in the projects with confidentiality and the intense efforts to comply with these restrictions affect compliance with the DO-200A Standard?

It is seen that the mean of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 2.88 and the standard deviation is 1.149. In this question, n = 11 of the 34 participants who participated in the research think that the confidentiality degree of the projects, due to the high degree of confidentiality, will affect the compliance with the standard or will critically affect the compliance with the standard. Here, it can be deduced that the existing restrictions are not an issue that will affect compliance due to the degree of confidentiality.

Question - 29

When the assigned duties / jobs are not clear, the emergence of communication deficiencies due to reasons such as lack of management, employees with a wide variety of work culture and employees with lack of motivation, to what extent do they affect compliance with the DO-200A Standard?

It is seen that the average of the answers given by means of the mean and standard deviation, which are the values we have reached through the frequency table, is 3.91 and the standard deviation is 0.753. In this question, n = 23 of the 34 participants who participated in the study, n = 23 stated that the uncertainty of the work given in the application of the DO-200A standard, the lack of communication and management of the employees with different working culture and the lack of motivation and the failure to solve their problems will affect the compliance or critically he thinks it will affect. Here, it can be deduced that problems arising mainly due to social or humanitarian situations cannot be solved due to administrative problems and lack of communication. In other words, employees need development, verification, validation, documentation, etc. that may cause incomplete, incorrect or overlooked situations. It turns out that their activities can also affect compliance with the standard. In order to solve this, the problems must be discussed clearly and administrative actions must be taken.

Table 5.7. Question - Mean Value Matrix

MEAN	QUESTION	Q NO
2.82	To what extent does the existence of DO-200B or other software quality standards claiming to meet the same requirements instead of the DO-200A standard, and not being able to use them affect compliance with DO-200A Standard?	13
2.88	To what extent do the restrictions arising due to the high degree of confidentiality in the projects with confidentiality and the intense efforts to comply with these restrictions affect compliance with the DO-200A Standard?	28
3.24	To what extent does benefiting from current technologies in projects where DO-200A Standard is used affect compliance with DO-200A Standard?	24
3.38	To what extent do activities such as integrating 3rd party software to the system to make an existing system compatible with DO-200A affect compliance with the DO-200A Standard?	14
3.38	To what extent do the busy working times in the working environment affect compliance with the DO-200A Standard?	27
3.41	To what extent do the thinking that the DO-200A Standard and the DO-178C Standard envisage the same processes and do the same works, the confusion of the concepts mentioned by the standards affect the compliance with the DO-200A Standard?	8
3.41	To what extent does updating process assets in the verification and validation of DO-200A standard affect compliance with DO-200A Standard?	18
3.41	To what extent does knowing the usage areas / purposes of the DO-200A Standard regardless of the projects that are trying to comply with the DO-200A Standard?	26
3.44	To what extent does knowing the purpose of use of DO-178C Standard affect compliance with DO-200A Standard?	2
3.47	To what extent does making any improvement suggestions for the defects and deficiencies seen in the processes, and then addressing this proposal affect compliance with the DO-200A Standard?	19
3.47	In the implementation of the DO-200A standard, how much does it affect compliance with the DO-200A Standard by obtaining services or consultancy by independent institutions that provide Compliance Verification Engineering and Consultancy services in the verification / validation and compliance processes?	5
3.59	To what extent does making a distinction between the data characteristics of the DO-200A standard (Accuracy, Resolution, Assurance Level, Traceability, Timeliness, Completeness, Format) according to their importance, that is, paying more attention and importance to providing the characteristics considered important, affect compliance with DO-200A Standard?	9

3.62	To what extent do the training (s) received in order to effectively implement the DO-200A standard affect compliance with the DO-200A Standard?	10
3.65	In the process of adapting to the DO-200A standard, to what extent does the confusion of application integrator and data generator concepts affect compliance with the DO-200A Standard?	7
3.71	In the implementation of the DO-200A standard, to what extent does the use of tool (s) that automate all steps in the verification / validation and compliance processes in an inclusive manner affect compliance with the DO-200A Standard?	6
3.71	The implementation of DO-200A Stadandard in aviation projects in the context of an organization, lack of validation and audit experience, etc. To what extent do situations affect compliance with DO-200A Standard?	22
3.74	Before the DO-200A Standard, in the implementation of the standard, in compliance and so on. To what extent does existence of managerial problems in processes affect compliance with DO-200A Standard?	25
3.79	How does the necessary coordination and communication with stakeholders in the implementation of the DO-200A standard, verification / validation and compliance processes affect compliance with the DO-200A Standard?	12
3.79	To what extent does the understandability of the DO-200A standard affect the compliance with the DO-200A Standard in the project that must comply with the standard?	15
3.88	Verification, validation, etc. of DO-200A standard. To what extent does audits by independent persons, institutions or authorities affect compliance with DO-200A Standard?	20
3.88	To what extent does understanding the DO-200A standard in all aspects and effectively affect compliance with the DO-200A Standard?	11
3.88	To what extent does the involvement of persons who have previously gained experience with the DO-200A Standard in the preparation of the procedures to be applied in the verification / validation of the DO-200A standard affect the compliance with the DO-200A Standard?	4
3.88	When the project plans and objectives are not clear in terms of DO-200A Standard, how does the emergence of conceptual confusion due to poor communication with stakeholders affect compliance with the DO-200A Standard?	23
3.91	To what extent does providing a supportive infrastructure in applying / testing / evaluating / configuring the DO-200A Standard affect compliance with the DO-200A Standard?	3
3.91	It is not clear which roles and responsibilities will be in the process of compliance with the DO-200A standard; for example, taking all responsibility on the software development team, etc. To what extent do situations affect compliance with DO-200A Standard?	16
3.91	When the assigned duties / jobs are not clear, the emergence of communication deficiencies due to reasons such as lack of management, employees with a wide variety of work culture and employees with lack	29

	of motivation, to what extent do they affect compliance with the DO-200A Standard?	
3.97	To what extent does the presence of gaps, deficiencies or overlooked points in the verification and validation of the DO-200A standard affect the compliance with the DO-200A Standard?	17
4.03	To what extent does knowing the purpose of use of DO-200A Standard in projects affect compliance with DO-200A Standard?	1
4.03	Verification, validation, compliance etc. in processes. To what extent does the lack of clarity on how the inspections will be carried out affect compliance with the DO-200A Standard?	21

5.2.1. Analysis of Questions According to Weighted Arithmetic Mean Calculation

5.2.1.1. Weighted Arithmetic Mean Calculation

In the field of statistics, the weighted arithmetic mean is usually a measure of central location to summarize the data set in the field of descriptive statistics. The weighted mean type that most uses it is the weighted mean average.

As a non-null data-set [x_1, x_2, …, x_n] and weight function for each element [w_1, w_2, …, w_n] given as, the formula for the weighted arithmetic mean can be calculated as Equation 2.

$$\bar{x} = \frac{w_1 x_1 + w_2 x_2 + \cdots + w_n x_n}{w_1 + w_2 + \cdots + w_n}. \tag{2}$$

The questions were calculated according to the formula in Equation 2 with the mean values obtained according to the factor mapping and the weights obtained as a result of the consensus reached with the expert opinions.

5.2.1.2. Analysis of Weighted Arithmetic Mean Results

For some questions, such a weighted average method was preferred because a factor was not fully compensable. The weighted mean takes into account the relative importance or frequency of some factors in a data set. In this way, it is thought that the method will give us more accurate results and therefore this method has been used.

1) F1: Lack of Communication

Table 5.8. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
1	To what extent does knowing the purpose of use of DO-200A Standard in projects affect compliance with DO-200A Standard?	0.6	0.6*4.03=2.418 +
13	To what extent does the existence of DO-200B or other software quality standards claiming to meet the same requirements instead of the DO-200A standard, and not being able to use them affect compliance with the DO-200A Standard?	0.4	2.82*0.4=1.128 +
23	When the project plans and objectives are not clear in terms of DO-200A Standard, how does the emergence of conceptual confusion due to poor communication with stakeholders affect compliance with the DO-200A Standard?	0.8	0.8*3.88=3.104 +
25	In the implementation, compliance, etc. of the DO-200A Standard. To what extent does existence of managerial problems in processes affect compliance with DO-200A Standard?	0.2	0.2*3.74=0.748 +
9	To what extent does making a distinction between the data characteristics of the DO-200A standard (Accuracy, Resolution, Assurance Level, Traceability, Timeliness, Completeness, Format) according to their importance, that is, paying more attention and importance to providing the characteristics considered important, affect compliance with DO-200A Standard?	0.2	0.2*3.59=0.718+
12	How does the necessary coordination and communication with stakeholders in the implementation of the DO-200A standard, verification / validation and compliance processes affect compliance with the DO-200A Standard?	1.0	1.0*3.79=3.79
	Total	3.2	11.906
	Weighted Arithmetic Mean		11.906/3.2 = 3.72

According to the weighted average calculation, the result was 3.72 for the Lack of Communication factor. According to the weighted average result, the participants are the developer, tester, qualityist, etc. It can be inferred that he thinks effective communication is important across all roles, as well as among all stakeholders.

2) F2: Lack of Training/Learning

Table 5.9. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
9	To what extent does making a distinction between the data characteristics of the DO-200A standard (Accuracy, Resolution, Assurance Level, Traceability, Timeliness, Completeness, Format) according to their importance, that is, paying more attention and importance to providing the characteristics considered important, affect compliance with DO-200A Standard?	0.4	3.59*0.4 = 1.436
2	To what extent does knowing the purpose of use of DO-178C Standard affect compliance with DO-200A Standard?	1.0	3.44*1.0 = 3.44
26	To what extent does knowing the usage areas / purposes of the DO-200A Standard regardless of the projects that are trying to comply with the DO-200A Standard?	1.0	3.41*1.0 = 3.41
10	To what extent do the training (s) received in order to effectively implement the DO-200A standard affect compliance with the DO-200A Standard?	1.0	3.62*1.0 = 3.62
7	In the process of compliance with the DO-200A Standard, to what extent does the confusion of application integrator and data generator concepts affect compliance with the DO-200A Standard?	0.5	3.65*0.5 = 1.825
8	To what extent do the thinking that the DO-200A Standard and the DO-178C Standard envisage the same processes and do the same works, the confusion of the concepts mentioned by the standards affect the compliance with the DO-200A Standard?	0.5	3.41*0.5 = 1.705
11	To what extent does understanding the DO-200A standard in all aspects and effectively affect compliance with the DO-200A Standard?	0.4	3.88*0.4 = 1.552
21	Verification, validation, compliance etc. in processes. To what extent does the lack of clarity on how the inspections will be conducted affect compliance with the DO-200A Standard?	0.5	4.03*0.5 = 2.015
16	It is not clear which roles and responsibilities will be in the process of compliance with the DO-200A standard; for example, taking all responsibility on the software development team, etc. To what extent do situations affect compliance with DO-200A Standard?	0.4	3.91*0.4 = 1.564
	Total	5.7	20.567
	Weighted Arithmetic Mean		20.567/5.7 = 3.60

According to the weighted average calculation, the result was 3.60 for the Lack of Training / Learning factor. According to the weighted average result, it can be deduced that the participants think it is important to receive DO-200A Standard training in order to comply with the DO-200A Standard.

3) F3: Insufficient Validation and Verification

Table 5.10. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
4	To what extent does the involvement of persons who have previously gained experience with the DO-200A Standard in the preparation of the procedures to be applied in the verification / validation of the DO-200A standard affect the compliance with the DO-200A Standard?	0.5	3.88*0.5 = 1.94
5	In the implementation of the DO-200A standard, how much does it affect compliance with the DO-200A Standard by receiving services or consultancy by independent institutions that provide Compliance Verification Engineering and Consultancy services in the verification / validation and compliance processes?	0.2	3.47*0.2 = 0.694
17	To what extent does the presence of gaps, deficiencies or overlooked points in the verification and validation of the DO-200A standard affect the compliance with the DO-200A Standard?	0.6	3.97*0.4 = 2.382
18	To what extent does updating process assets in the verification and validation of DO-200A standard affect compliance with DO-200A Standard?	0.3	0.3*3.41 = 1.023
	Total	1.6	6.039
	Weighted Arithmetic Mean		6.039/1.6 = 3.77

According to the weighted average calculation, the result was 3.77 for the Insufficient Validation and Verification factor. According to the weighted average result, the participants, in order to comply with the DO-200A Standard, the deficiencies that may occur in the process of compliance with the DO-200A Standard, especially in the verification and validation steps, points that are not in the eye, etc. It can be deduced that he thinks it is important.

4) F4: Independent Controls/Audits

Table 5.11. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
20	Verification, validation etc. of DO-200A standard. To what extent does audits by independent persons, institutions or authorities affect compliance with DO-200A Standard?	1.0	3.88*1.0 = 3.88
	Weighted Arithmetic Mean		3.88/1.0 = 3.88

According to the weighted average calculation, the result was 3.88 for Insufficient Validation and Verification factor. According to the weighted average result, it can be deduced that the participants think that independent controls and reviews are important in the process of compliance with the DO-200A Standard, especially in the verification and validation steps, in order to comply with the DO-200A Standard. However, the thought that it poses a threat to us due to the low number of questions is not ignored.

5) F5: Tool Qualification

Table 5.12. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
6	In the implementation of DO-200A Standard, to what extent does the use of tool (s) that automate all steps in the verification / validation and compliance processes in an inclusive manner affect compliance with the DO-200A Standard?	1.0	3.71*1 = 3.71
3	To what extent does providing a supportive infrastructure in applying / testing / evaluating / configuring the DO-200A Standard affect compliance with the DO-200A Standard?	0.7	3.91*0.7 = 2.737
	Total	1.7	6.447
	Weighted Arithmetic Mean		6.447/1.7 = 3.79

According to the weighted average calculation, the result was 3.79 for the Tool Qualification factor. According to the weighted average result, it can be deduced that the participants think it is important to use automated tools and supportive infrastructure that can be used in the processes of compliance with the DO-200A Standard, verification and validation. However, the thought that it poses a threat to us due to the low number of questions is not ignored.

6) F6: Understandability

Table 5.13. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
14	To what extent do activities such as integration of 3rd party software to make an existing system compatible with DO-200A affect compliance with the DO-200A Standard?	1.0	3.38*1.0 = 3.38
15	To what extent does the understandability of the DO-200A standard affect the compliance with the DO-200A Standard in the project that must comply with the standard?	1.0	3.79*1.0 = 3.79
16	It is not clear which roles and responsibilities will be in the process of compliance with the DO-200A standard; for example, taking all responsibility on the software development team, etc. To what extent do situations affect compliance with DO-200A Standard?	0.6	3.91*0.6 = 2.346
	Total	2.6	9.516
	Weighted Arithmetic Mean		9.516/2.6 = 3.66

According to the weighted average calculation, a result of 3.66 was obtained for the Understandability factor. According to the weighted average result, the participants are the developer, tester, qualityist etc. who try to apply the standard in order to comply with the DO-200A Standard. It can be deduced that he considers effective communication among all roles as well as among all stakeholders as important.

7) F7: Lack of Experience

Table 5.14. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
9	To what extent does making a distinction between the data characteristics of the DO-200A standard (Accuracy, Resolution, Assurance Level, Traceability, Timeliness, Completeness, Format) according to their importance, that is, paying more attention and importance to providing the characteristics considered important, affect compliance with DO-200A Standard?	0.4	0.4*3.59=1.436
7	In the process of compliance with the DO-200A Standard, to what extent does the confusion of application integrator and data generator concepts affect compliance with the DO-200A Standard?	0.5	3.65*0.5 = 1.825

8	To what extent do the thinking that the DO-200A Standard and the DO-178C Standard envisage the same processes and do the same works, the confusion of the concepts mentioned by the standards affect the compliance with the DO-200A Standard?	0.5	3.41*0.5 = 1.705
11	To what extent does understanding the DO-200A standard in all aspects and effectively affect compliance with the DO-200A Standard?	0.6	3.88*0.6 = 2.328
21	Verification, validation, compliance etc. in processes. To what extent does the lack of clarity on how the inspections will be conducted affect compliance with the DO-200A Standard?	0.5	4.03*0.5 = 2.015
4	To what extent does the involvement of persons who have previously gained experience with the DO-200A Standard in the preparation of the procedures to be applied in the verification / validation of the DO-200A standard affect the compliance with the DO-200A Standard?	0.5	3.88*0.5 = 1.94
5	In the implementation of the DO-200A standard, how much does it affect compliance with the DO-200A Standard by receiving services or consultancy by independent institutions that provide Compliance Verification Engineering and Consultancy services in the verification / validation and compliance processes?	0.2	3.47*0.2 = 0.694
17	To what extent does the presence of gaps, deficiencies or overlooked points in the verification and validation of the DO-200A standard affect the compliance with the DO-200A Standard?	0.4	3.97*0.4 = 1.588
22	The implementation of DO-200A Stadandard in aviation projects in the context of an organization, lack of validation and audit experience, etc. to what extent do situations affect compliance with DO-200A Standard?	1.0	3.71*1 = 3.71
	Total	4.6	17.241
	Weighted Arithmetic Mean		17.241/4.6 = 3.74

According to the weighted average calculation, a result of 3.74 was obtained for the Understandability factor. According to the weighted average result, in the implementation of DO-200A standard, it can be deduced that the participants think that the verification and validation processes that have organizational experience and consequently experienced personnel help, transfer their knowledge and experience will involve less problems and errors and experience less delays. In other words, it will be difficult for an institution with a lack of experience to produce a product that complies with the standard. In order to prevent problems caused by lack of experience, measures such as various consultancy services, provision of experienced personnel can be taken.

8) F8: Lack of Management

Table 5.15. Question – Weighted Arithmetic Mean Value – Descriptive Statistic Matrix

Q No	Question	Weight	Descriptive Statistic
1	To what extent does knowing the purpose of use of DO-200A Standard in projects affect compliance with DO-200A Standard?	0.4	0.4*4.03 = 1.612+
13	To what extent does the existence of DO-200B or other software quality standards claiming to meet the same requirements instead of the DO-200A standard, and not being able to use them affect compliance with the DO-200A Standard?	0.6	2.82*0.6 = 1.692+
23	When the project plans and objectives are not clear in terms of DO-200A Standard, how does the emergence of conceptual confusion due to poor communication with stakeholders affect compliance with the DO-200A Standard?	0.2	0.2*3.88 = 0.776+
25	In the implementation, compliance, etc. of the DO-200A Standard. To what extent does existence of managerial problems in processes affect compliance with DO-200A Standard?	0.8	0.8*3.74 = 2.992
18	To what extent does updating process assets in the verification and validation of DO-200A standard affect compliance with DO-200A Standard?	0.7	0.7*3.41 = 2.387
3	To what extent does providing a supportive infrastructure in applying / testing / evaluating / configuring the DO-200A Standard affect compliance with the DO-200A Standard?	0.3	0.3*3.91 = 1.173
19	Implementation / verification of DO-200A standard etc. To what extent does making any improvement suggestions for the defects and deficiencies seen in the processes, and then addressing this proposal affect compliance with the DO-200A Standard?	1.0	3.47*1.0 = 3.47
24	To what extent does benefiting from current technologies in projects where DO-200A Standard is used affect compliance with DO-200A Standard?	1.0	3.24*1.0 = 3.24
27	To what extent do the busy working times in the working environment affect compliance with the DO-200A Standard?	1.0	3.38*1.0 = 3.38
28	To what extent do the restrictions arising due to the high degree of confidentiality in the projects with confidentiality and the intense efforts to comply with these restrictions affect compliance with the DO-200A Standard?	1.0	2.88*1.0 = 2.88
29	When the assigned duties / jobs are not clear, the emergence of communication deficiencies due to reasons such as lack of management, employees with a wide variety of work culture and employees with lack of motivation, to what extent do they affect compliance with the DO-200A Standard?	1.0	3.91*1.0 = 3.91
	Total	8.0	27.512
	Weighted Arithmetic Mean		27.512/8.0 = 3.439

According to the weighted average calculation, the result was 3.44 for the Lack of Management factor. According to the weighted average result, it can be deduced that the participants think that the situations that may lead to lack of management such as making the decisions required to comply with the DO-200A Standard on time and the clarity of the work to be done are important. The Lack of Management factor, which stands out as the factor that is linked to the most questions, gives a greater margin of accuracy.

How Are The Weights Determined?

The weights were determined as a result of the consensus reached with the thesis supervisor after the information obtained from the literature and the feedback from the experts in order to reveal which factor is more effective and more important in a question. In addition, the thought that the weighted average produces more accurate results and the observation that the weights directly change the factor effects have been one of the important issues. The weights were determined by matching the meaning extracted from the questions with the factors obtained in the study. For example, looking at the 7th Question, there is such a problem due to the complexity of the concept and context, there is no training on DO-200A Standard (Lack of Training / Learning - F2), so there is no knowledge and there is a lack of experience on this subject (Lack of Training / Learning - F2). of Experince - F7). No discussion was deemed necessary for the questions of close weight.

6. CONCLUSION

This thesis focuses on investigation of factors affecting the adoption of DO-200A Standard. In thesis, we scanned the literature with our long-term SMS study. We combined the information and factors obtained from this screening with expert opinions and revealed various factors. The obtained factors were adapted to a questionnaire to assess whether they affect compliance with the standard and applied to 34 participants with experience in DO-200A. The responses to the questionnaire were subjected to various analyzes in the statistical analysis tool SPSS. The results obtained after these analyzes were already discussed in section 5. Now a final comparison and evaluation of the results will be made, followed by the recommendations for adoption.

6.1. Comparison of Results

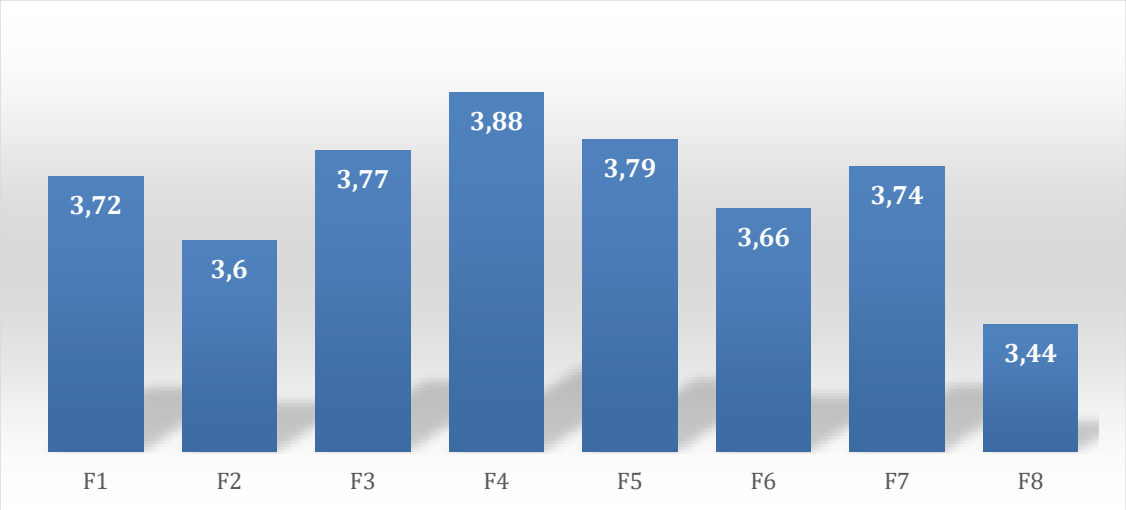

Figure 6.1. Comparison of factors

Among the factors, we can see that the Lack of Communication (F1), Lack of Training / Learning (F2) and Lack of Management (F8) factors, which were matched with more questions, got lower mean values. From this, it can be concluded that as the number of questions increases, we can reach more accurate values. The Lack of Experience (F7) factor is high in number of questions and stands out as the factor that gives the most successful result. The Independent Controls / Auidts (F4) factor, which is 0.09 points higher than its closest competitor, became the factor with the highest value with a value of 3.88. It was observed that the Lack of Management (F8) factor was the lowest with

3.44, and when other ranges were considered, it was observed to be at the bottom with a larger interval.

We see that the factors F5, F3, F7 and F1 get very close results. This leads us to think that these factors are equally important. We mentioned that the factors were obtained from literature review and expert opinions. The Lack of Communication factor was the one that gave the closest result to the literature. The Lack of Experince factor, which was obtained in the literature review but was not included due to its mention in a few studies, was one of the determining factors.

6.2. Limitations and Recommendations for Future Work

One of the limitations of this research was its scope. This study validated the proposed research model on the DO-200A Standard. In order to generalize the findings, further research on different standards by using this model is needed.

The other limitation was the small number of survey participants. The obtained factors were adapted to a questionnaire to assess whether they affect compliance with the standard and applied to 34 participants with experience in DO-200A. This situation also affected the statistical methods used to analyze the questionnaires. Other methods except than descriptive statistics could not get a result.

Companies that will develop software in accordance with the DO-200A standard for the first time and implement standards such as AQAP-160, CMM may face some difficulties and compliance problems. Beyond that, the additional workforce brought about by the implementation of DO-200A can be realized much more than it should be. Worst of all, there will be problems in the certification process at the end of the project, which may require repeating the entire process. In order to minimize such risks, it is necessary to know the unseen aspects of the subject that can only be gained with experience. In this section, we will try to convey some information about our experiences and problems. Developing software for airworthiness certification; It should not only be understood as reading, understanding and applying the DO-200A document, which is the standard of this work. In order to meet the objectives described in this document, it is necessary to establish a certain business logic and knowledge. From this know-how, from the document templates used by the institution, to the automatic test tools used, to software development methods, an institutional know-how that can be gained in a very long time should be understood. It should not be forgotten that; process equals not a document! In the subsections, the options that can be applied to provide DO-200A compatibility to the

existing knowledge of software companies as soon as possible are given the issues that need to be considered.

6.2.1. Harmonization of Corporate Knowledge Base

Some of the ways we have identified to adapt the corporate knowledge base to this standard in the fastest way are;

- Getting training,
- Getting consultancy service,
- Hiring DER (Designated Engineering Representative),
- Being a part of a project that requires certification.

Training

One week of DO-200A training can be taken from one of the three or four major organizations worldwide specialized in this field. In this way, DO-200A compliance can be achieved quickly with human resources in a project subject to certification. In these trainings, invaluable resources such as document templates, checklists that can be used to create process outputs are also provided. One disadvantage of this option is that practice habits cannot be changed during a week of intensive training. Therefore, our recommendation should not be that this option alone will be sufficient, and one of the next three options should be applied.

Getting Consultancy Service

The major organizations providing training also offer consultancy services. Consultancy can either be in order to eliminate the problems that arise from time to time at certain intervals, or it can be in the form of monitoring the appropriateness of the progress of the project throughout the project.

Rent DER

DER is an independent expert who can examine the process authorized and approved by the certification authority and control the progress by providing feedback. In projects requiring airworthiness certification, it is already a necessity to have a DER assigned to the project. In a DO-200A project where certification is not required, but required to be certified, it can be continued by obtaining approval at every stage of the project by renting a DER at the beginning of the project. Thus, our project will be automatically approved

at the end of the project. However, this method is not preferred in military projects, especially in military projects where certification is not required and only a quality standard is aimed.

Being a subcontractor in a project that requires certification

If there is such an opportunity, this may be the most appropriate and efficient option for a company that will develop DO-200A compatible software for the first time. In this case, the top contractor will mostly follow up the process and guide you as required. Most likely, the top contractor will have hired a DER or receiving consultancy services. The subcontractor company will also be able to benefit from these opportunities. All process outputs will be reviewed by the subcontractor firm and, in a sense, the responsibility will be distributed.

6.2.2. Changing the Tightness of the Process According to the Safety Level

It should be kept in mind that in DO-200A, software is classified according to safety levels, the tightness of the process changes according to these levels and the targets expected to be met decrease as the level decreases. Software companies applying a certain process pass all software products through the same process. If the levels are not noticed in DO-200A, unnecessary work can be done by sticking to this logic. Falling into this situation should be avoided!

6.2.3. Documentation Adaptation

The process outputs defined in DO-200A are largely the same with the outputs of software development processes accepted in the world. Besides, special for DO-200A There may be some additional output. There may be outputs that are not in the process of our company, but desired in DO-200A. These outputs should be defined and enumerated and included in the configuration management system. Another issue is document templates. DO-200A does not prescribe a specific template for documents. Only topics that should be included in each document are listed. However, it is important that the documents that come to the certification authorities in the certification process are in a certain order, in other words, the fact that the certification authorities are in the familiar structure is important in terms of speeding up and facilitating the certification process. For this reason, it would be appropriate to compare the document templates with the DO-200A

compliant templates obtained from consulting companies or other sources, and to update them if necessary.

6.2.4. Required Compatibility in Software Development Environment and Tools

Each software company has a software development environment and tools used by each software developer depending on the type of software they develop, and various software libraries they use. These tertiary sources, which have a great contribution / impact on the production of software in standard software development processes, are not questioned much. However, anything that affects the software product in the DO-200A standard is subject to certification, so they also need to be approved. Software tools are divided into two classes; software development tools, software verification tools.

- Software development tools: Tools that are part of the software fall into this category. For example, tools or compilers that automatically generate code from design. If the output produced by such tools will not be verified according to DO-200A verification methods, this tool must be a qualified tool.
- Software verification tools: Tools in this class; They are described as tools that are not part of the software, but can prevent the detection of errors because they affect the process. For example testing tools, analysis tools, static code analysis tools.

If the outputs produced by these tools are to be used without being verified according to DO-200A, these tools must be approved. According to DO-200A, whether a tool used in the software life cycle should be approved or not can be determined according to the answers given to the following three questions.

1. Can this tool generate errors within the software product or prevent an existing bug from being detected?
2. Will the output of this tool not be verified in DO-200A validation steps?
3. Does this tool automate or simplify DO-200A processes?

If the answer to these three questions is yes, this tool must be approved.

Apart from software tools, the libraries or Commercial Off-The-Shelf (COTS) products that we will use in our software must also be certified or made in accordance with DO-200A standards by us. This situation causes us not to benefit from a very large software archive formed in the world for ready-made libraries that we can use and to be limited to very limited certified products. Due to these constraints, software companies may have

to put aside their own software libraries and software development environments they have created for a long time, search for new resources and create a new development environment, which is a huge obstacle in terms of both cost and time.

Tools in software engineering have a variety of uses throughout the software life cycle. Some are helpful, such as checking whether the source code is compatible with a coding standard, calculating the maximum heap usage, or detecting references to uninitialized variables. Others affect executable code such as the code generator for a model-based design. The tools can save significant manpower, but we must be confident that their outputs are correct; otherwise, we have to manually verify the output.

With DO-200A, we gain this confidence through a process called Tool Qualification, which is proof that the tool meets its operational requirements. The level of effort required - the tool qualification level in question or TQL (Tool Qualification Level) - depends on the DAL of the software the tool will operate and in the presence of any of the "existing" scenarios. Tool error:

- Criterion 1: The tool output is part of the aviation software and the tool may generate an error.
- Criterion 2: The tool was unable to detect a bug and its output was used to reduce other development or verification activities.
- Criterion 3: The tool could not detect an error.

TQLs range in criticality from 5 (lowest) to 1 (highest). TQL-1 applies to an instrument that meets Criterion 1 and is used for software in DAL A. Most static code analysis tools will be in TQL-4 or TQL-5.

An auxiliary standard DO-330 (Tool Qualification Considerations) defines specific objectives, activities, and data items associated with various TQLs. DO-330 can be used with other software standards; It is not specific to DO-200A.

Because of the volume of data and the need for repeatability, aeronautical data processing is tool intensive. Typically, a combination of integrity checks (such as cyclic redundancy checks) and qualified tools are used to ensure the integrity of the aeronautical data as they go through the data chain. Sometimes, tools are run in parallel and results compared to avoid the need for qualification. All tools must be identified and assessed. Tools whose output is not verified may require qualification. DO-330 was written to be applicable to multiple domains, including the aeronautical data domain.

Audit procedures can be implemented using a variety of tools and techniques, which can be automated or manual (often manual). Various terms can be used in practice to describe tools and techniques that are automated by auditors. Tasks of these tools:

- Assisting the audit team in planning and implementation of the audit.
- To direct the independent audit.
- Ensuring that the audit team is responsible for its own work.
- Ensuring that the issues that will be important in future audits are recorded.
- DO-200A is a documented standard. To provide the necessary automation to ensure this certification.

In the light of the factors and analyzes we have obtained, tool use and tool qualification information, we conclude that the use of tools for various purposes in compliance with the DO-200A Standard will further facilitate and automate compliance, and further reduce errors and problems.

6.2.5. Gap Analysis

Every firm that develops software professionally has a certain software development process. The work done to determine the processes and process outputs that need to be corrected and / or added to comply with the DO-200A Standard is called Gap Analysis. Various consultancy companies provide this service around the world. Such a difference analysis study can be completed in a period of 2-4 man / week provided that an expert who knows the processes of the institution where the analysis will be carried out is included in the study. Such an approach can be applied as a solution to insufficient validation and verification, which is one of our factors.

It is seen that DO-200A Standard will become more widespread in the future and will cease to be mentioned only with civil aircraft. In this case, it will be in the interest of organizations that develop safety-critical software to prepare themselves in this regard. When entering such a project, it is necessary to be aware of the extra cost and labor force that this standard will bring, and planning and risk analysis should be done accordingly. In our thesis, the experiences gained through a study aimed at raising awareness on DO-200A, some risk factors, DO-200A and related issues were tried to be presented together with a general.

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APPENDICES

APPENDIX A: PRIMARY STUDIES

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APPENDIX B: INSTRUMENT

To access the survey:

https://docs.google.com/forms/d/e/1FAIpQLSdKl0eUn_j0hrbtHxuRxonJiAMsOLAdsPLEXlJfTL_-p5MAaw/viewform?usp=sf_link

Survey Instrument:

DO-200A Kalite Standardı Üzerine Anl