THE REPUBLIC OF TURKEY
BAHCESEHIR UNIVERSITY

AGILE SOFTWARE DEVELOPMENT PROJECT EVALUATION BY FUZZY AHP IN THE VIEW OF CRITICAL SUCCESS INDICATORS' SUCCESS AND FAILURE RESEARCH

Master's Thesis

SEYDİ MİHMANLI

ISTANBUL, 2016

THE REPUBLIC OF TURKEY

BAHCESEHIR UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
COMPUTER ENGINEERING (ENGLISH - THESIS)

AGILE SOFTWARE DEVELOPMENT PROJECT EVALUATION BY FUZZY AHP IN THE VIEW OF CRITICAL SUCCESS INDICATORS' SUCCESS AND FAILURE RESEARCH

Master's Thesis

SEYDİ MİHMANLI

Supervisor: Assoc. Prof. Dr. Dilek KARAHOCA

ISTANBUL, 2016

THE REPUBLIC OF TURKEY

BAHCESEHIR UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
COMPUTER ENGINEERING (ENGLISH – THESIS)

Name of the thesis: Agile Software Development Project Evaluation by Fuzzy AHP in the view of Critical Success Indicators' Success and Failure Research
Name/Last Name of the Student: Seydi MİHMANLI
Date of the Defense of Thesis: 20/05/2016

The thesis has been approved by the Institute of Science..

Assoc. Prof. Dr. Nafiz ARICA
Graduate School Director

I certify that this thesis meets all the requirements as a thesis for the degree of Master of Science..

Ph.D. Tarkan AYDIN
Program Coordinator

This is to certify that we have read this thesis and we find it fully adequate in scope, quality and content, as a thesis for the degree of Master of Science.

Examining Committee Members	Signature
Thesis Supervisor	
Assoc. Prof. Dr. Dilek KARAHOCA	_____
Thesis Co-Supervisor	
Prof. Dr. Adem KARAHOCA	_____
Member	
Prof. Dr. İbrahim PINAR	_____

ACKNOWLEDGMENTS

I would like to express my thankful to my thesis supervisors, Doç. Dr. Dilek KARAHOCA and Prof. Dr. Adem KARAHOCA, for their endless support in every phase on my study.

I would like to thank NETAŞ for bearing me out for everything especially monetary aspect and supporting cooperation program with BAHCESEHIR University and help me to finish my post-graduation.

I would like to thank to my colleagues and friends who do not hesitate to answer all questions on survey.

I would like to thank my colleagues Harun ÇALIŞKAN and Şenay DEMİREL for high motivation and amusing time.

I would like to say in addition of thankful to Korhan YAZGAN and Mesut YALÇIN for easing my all works.

And finally, to my wife Bilge: Really appreciate your patience, support and love…

Istanbul, 2016 Seydi MİHMANLI

ABSTRACT

AGILE SOFTWARE DEVELOPMENT PROJECT EVALUATION BY FUZZY AHP IN THE VIEW OF CRITICAL SUCCESS INDICATORS' SUCCESS AND FAILURE RESEARCH

Seydi Mihmanlı

Computer Engineering

Supervisor: Assoc. Prof. Dr. Dilek KARAHOCA

May 2016, 79 pages

In this thesis study, Fuzzy AHP had been investigated, and then it applied on Success Criterions of Agile Software development process.

Firstly, success criterions of agile process were gathered in five categories and these categories called as "main criterions". Each Main criterion made of a few sub-criterions and each sub-criterion also composed of more than detail criterions.

Secondly, effect of each detail criterions on a Project which is developed by applying agile process was measured by means of a survey. All participants who answered the survey have experience both software development and agile software development process.

Finally, all answers which were given by experienced engineers were mapped to the detailed criterions and next phase, Fuzzy AHP execution on collected data by means of survey, was started. In this phase, Buckley method was used due not to be possible to find consistency ratio by using Chang Method. Thanks to Buckley Method, all detailed-criterions under a main criterion were prioritized and consistency ratio was calculated. Detail criteria who belongs to the main criteria of Agile Software Development

Keywords: Fuzzy AHP, Buckley Method, Agile Software Development Process

ÖZET

ÇEVİK METODOLOJİSİ VE KRİTİK BAŞARI FAKTÖRLERİ İLE BAŞARI VE BAŞARISIZLIK GÖSTERGELERİNİN FUZZY AHP KULLANILARAK ÖNCELİKLENDİRİLMESİ

Seydi Mihmanlı

Bilgisayar Mühendisliği

Tez Danışmanı: Doç. Dr. Dilek KARAHOCA

Mayıs 2016, 79 sayfa

Bu tez çalışmasında, bulanık analitik hiyerarşik proses araştırılarak Çevik Yazılım Geliştirme Sürecinin başarı kriterleri üzerinde uygulaması yapılmıştır.
İlk Bölümde Çevik Yazılım Geliştirme Süreçlerinin başarı kriterleri beş ana başlıkta toplanmış ve bunlara ana kriter adı verilmiştir. Bu ana kriterler kendi aralarında alt kriterlere ve alt kriterler ise kendi aralarında detay kriterlere ayrılmıştır.

İkinci Bölümde her bir detay kriterin Çevik Yazılım Geliştirme Süreci kullanılarak geliştirilen bir proje üzerindeki etkisi bir anket yardımıyla hem yazılım konusunda hem de Çevik Yazılım Geliştirme Süreci konusunda tecrübeli olan mühendislerin fikirleri alınmıştır.

En son olarak, tecrübeli mühendislerin anket sorularına vermiş oldukları cevaplar, soruların ait olduğu detay kriterlerle eşleştirilmiş ve bulanık analitik hiyerarşik proses aşamasına geçilmiştir. Bu aşamada Chang'ın metodunda tutarlılık oranının hesaplanabilmesi mümkün olmadığından dolayı Buckley'in metodu uygulanarak Çevik Yazılım Geliştirme Süreçlerinde belirlenmiş olan ana kriterlere ait detay kriterler arasında önceliklendirme yapılmış ve her bir ana kritere ait alt kriterler grubunun tutarlılık oranları hesaplanmıştır.

Anahtar Kelimeler: Bulanık Analitik Hiyerarşik Proses, Buckley Metodu, Çevik Yazılım Geliştirme Süreci

CONTENTS

TABLES

FIGURES

ABBREVIATIONS

AHP	:	Analytical Hierarchy Process
AM	:	Agile Manifesto
XP	:	Extreme Programming
ASD	:	Adaptive Software Development
DSDM	:	Dynamic System Development Method
CSF	:	Critical Success Factors
PAS	:	Prioritization and Selection
SA	:	Strongly Agree
AGG	:	Agree
NAD	:	Neither Agree or Disagree
DAGG	:	Disagree
SD	:	Strongly Disagree

1. INTRODUCTION

1.1 INTRODUCTION TO STUDY

Successful completion of software projects is critically important for all project partners. Unfortunately, a large number of the software projects in our country like it is in entire world, can be completed with overtime, over budget and/or without providing customer expectations(challenged projects) or canceled before they are completed or they are not utilized although they are delivered (failed projects).

Even in short time, Turkey has reached a high capacity in software industry, typical problems and failures are seen in software projects and projects are generally completed by difficulties. According to experiences of the authors, especially in privatized software (custom software) service purchases of public bodies without professional support, a lot of problems is being faced. This problems is started with the preparation of technical specifications, continues during implementation of project until the acceptance or denial of the project. In this case, story of acorporate automation software that is undertaken by a small software company, has been taken. Besides all, people factor should not be ignored.

Day by day, it is basically seen that software Project are getting huge and software projects are increasing fastly. 20 years ago, there were a few programming languages which are close to machine language such as Pascal, but now the most used programming languages are close to human language like Java, c#, Python. These languages are so easy to learn for a new graduated engineer. The qualifier engineers brings successful Project. On the other hand, an engineer believes that he is a software engineer as soon as he/she learnt any programming language. Agile's some principles such as working with customer closely, delivering frequently, being a part of team, importance of adaptation shall help a new graduated engineer in order to be improved himself

For analyzing the process and results systematically and in an objective way, study with name 'critical success factors' which is recommended in literature, has been based on. Our goal is sharing our experiences and results of our analysis with other software engineers and assisting for determining the software which has similar symptoms and go towards failure.

1.2 INTRODUCTION TO AGILE

All principles which mentioned at Agile Manifest and which was adopted by Agile Methodologies are used in order to solve some problems at most of software companies. In addition, using agile methodology is increasing more on more. In case of a comparison with basic thinking, Agile decreases waste of time, source and Money; Agile destroys all activity which are not provide any benefit to customer.

Agile Manifest,(Agile Manifesto 2001)

a. prefers people and their relationship rather than a tool
b. prefers working software rather than wide documentation
c. prefers cooperation with customer rather than formal agreement
d. prefers answering to changes in every phase of Project rather than immutable plans

Basic principles can be ordered according to Agile Manifest (2001):

Provide customer satisfaction by developing faster, continuous and useful software. After Project implementation starts, code is delivered ones a three or four weeks. Thus, feedbacks which will come from customer can be applied fastly. It must not be forgotten that for a product, the best tester is always customer.

Changes coming from customer should be accepted on every phase of Project. Agile Manifest advocates that if customer realizes a new requirement for new-product which is being developed. This new requirement should be accepted even if product is almost completed. Because the main purpose should be making useful product for customer.

Otherwise, in case of applying immutable plan, customer will have a product which is not useful.

Developers and other engineers who have experience on different subject should work closely. While a group of engineer is being gathered in order to develop a product, not only software engineers also software architecture, analyst, tester should be located in that group. They should cooperate altogether.

Developer should be self-motivated and self-organized. A person who is out of Project should not motivate anyone in group. This group should be self-decision maker and self-motivated.

Best way for communication is face to face. Face to face communication is more useful than both using telephone and sending e-mail. This provides fast response, reliable answer. Also avoids misunderstanding.

Steady code particles lead to success. Even if a function is written, it should be immediately tested. This method avoids future-fails

Neither slowly nor fastly, sustainable speed is the best. An engineer can work overtime for a week or two weeks, but he cannot resist all development time. Team should have sustainable speed and all plan should be made according to this speed.

Good design and best technique would develop agile. During designing, ready design patterns should be applied. Thus, expandable code would be written easily

Simplicity is important. Agile Manifest says that use simple solution. Thus code can be changed easily, can be understood easily and the most important reason is to get rid of waste of time and source.

Design should be made by team members. The best architectures, requirements and designs are created by self-organized teams.

Team is gathered periodically and decides what to do and how to do. To work more efficiently and effectively, team takes common decisions and gather may be every morning in order to review each other's studies.

Agile methodologies accept the manifest which mentioned above and its study methods.

1.2.1 Extreme Programming (XP)

It is an agile method that is very popular in recent years and it has been defined by Kent Beck. XP is a software development method that is based on simplicity, communication, feedback and courage. In detail, it contains applications like planning game, frequent releases, metaphor, simple design, reorganization, binary coding, common ownership, continuous integration, 40 hour work, customer participation, coding standard, open job posting.

1.2.2 Adaptive Software Development

ASD, has been developed by Jim HighSmith for complex and large-scale systems. It strongly encourages method increment, repetitive and constant prototyping. Method aims to provide a framework for preventing projects to slide into chaos without suppressing the creativity. This process consists of three stepwise cycles. These are speculating, collaborating and learning cycles respectively. It has applications like incremental development, feature based planning and customer-oriented group reviews (Abrahamson 2002).

1.2.3 Agile Modelling

Agile modelling has been developed by Scott W. Ambler by considering extreme programming assets and has been taken its final form by adding modesty in it. The main idea is encouraging developers to create sufficiently improved but as least as possible models and support them for significant design problems and documentation. Communication, simplicity, feedback, doing modelling as team, examining your model

with right people, application of the model, acceptance tests, courage, modesty are the most important assets it has (Ambler &Jeffries 2002)

1.2.4 Scrum

Scrum is a dynamic process which is introduced by Ken Schawaber. Scrum constantly interested in how the functions of team members must be in a changing environment
Instead of defining software development techniques for software design and put software into practice. (Stojanovic 2004). The main idea in the Scrum is; any resource like technology, deadlines may change during the process. This makes it mandatory flexibility to respond to change (Abrahamson 2002). There are three stages; pre-game, development, post-game. Scrum teams are self-oriented and do not require any external guidance. Scrum teams should have maximum 10 members and a scrum development must be completed in a 30 day cycle (Stojanovic 2004)

1.2.5 Feature Driven Programming

It is a process based on the idea of development of small pieces of software which are usable in a continuous way. It consists of following steps; development of the whole modal, creating a list of features, feature based plans, feature based design, feature based development. A feature is a function that created from customer specific form which consists of <action>, <result>, <object> pairs. These features must be prioritized and each of them must be completed in two weeks.
This approach is applied to projects which are very critical and have 50 to 250 members using the UML, unlike the other agile approaches (Stojanovic 2004).

1.2.6 Dynamic System Development Method

It is a fast software development methodology which is introduced by DSDM the commission in UK. When it is compared with UP, Scrum; DSDM holds much more details and mostly used in the development process of fixed period software projects like government projects. During the software development process it has frequent

releases, active members, and testing principles. This method consists of reuse of functionality, design, and putting practice processes. DSDM aims to solve the problem small circular prototypes. In this method check lists and quality criteria preferred instead of huge documentation (Stojanovic 2004).

2. LITERATURE REVIEW

2.1 RESEARCH OVERVIEW

Nowadays a lot of Software Company follows the Agile software development methodology which is always in contact with the customers and suggests delivering the code in short time periods and defends that running codes is more important than detailed documents. In the Agile manifesto, general rules are defined for the companies which used software development methodology. But in the practice, usability of these rules or order of importance of these rules are mentioned in here and afore similar thesis.

Thanks to this and similar thesis, researcher defined the main criteria according to the Agile manifesto and created a survey by reducing the main criteria to sub and detail criteria and preparing one or more questions for every detail criteria. With the help of this survey, they sort the criteria, which are created by taking views of experienced people on software, according to the order of importance. The researchers use the Fuzzy logic and pairwise comparison in this phase, and calculate the consistency rate to be sure on accuracy of the obtained result.

2.2 LITERATURE LIST

When it is looked at this thesis study or similar previous thesis studies, it can be seen that two main concept are focused.

a. Critical Success Factors(CSF) on Agile Methodology
b. Fuzzy Analytical Hierarchy Process(Fuzzy AHP)

So, literature list consists of these two concept researches in here.
For literature based study;

Mougouei, Shen, Babar(2015) says that one of the important concern of Agile software development is requirements of prioritization and selection (PAS). Both binary selection of requirements and postponing lower-priority requirements to the future are primarily known existing PAS techniques. As a result, lower-priority requirements may be constantly delayed until they never have a chance to be implemented at all. However, ignoring lower-priority requirements may threaten the quality of software. They proposed partial selection concept as another way to Agile software requirement's binary selection rather than either ignoring them altogether or postponing them to the future releases in that paper. They further contributed a goal-oriented framework and they aimed to specify the fuzzy priority of requirements and accomplish partial selection through relaxing the satisfaction level of requirements with respect to their priority in the release backlog of software with this framework. This study showed them that the numbers of neglected requirements are reduced by partial selection of requirements if compared to binary selection.

Alpaslan (2015) advocated that Agile development is a method that is produced in order to eliminate the disadvantages of the classical development method. Developing the agile method and combining it with the model-driven method is thought to increase the software achievement. For this purpose, some methodologies combining these two methods are suggested. In this thesis, the agile model-driven methodologies in literature are explored and a new approach for using the web applications is developed. This approach is implemented with the student projects in "Software Engineering" class in our university and the results are evaluated.

Demirtas, Tuzkaya and Seker(2014) discussed agile methodologies' implementing outcomes to software development. In that study, reliable results are obtained by using decision making technique(multi-criteria). Firstly, various criteria, which is related with project management, are defined by using SWOT. Then thanks to Fuzzy AHP, selection criteria are weighted and specified.

Elibol (2014) prepared a comparative study which is there are many points to take into consideration during the development of mobile application in order to design the

application to work with the highest performance on these devices since every mobile device has specificities and limitations. It is very important that mobile applications reflecting the changing market conditions and customer demands in mobile application market take their places in the market in the fastest way. In order to achieve this, the process of developing mobile application should be maintained with a flexible structure. In today's software projects, needs continuously change within the process in company with the advancing technology. In this process, agile methodologies offer a flexible structure and enable the maintenance of the project process in line with the changing customer demands and advancing technology in order to give an answer to the inevitable changes. Scrum, one of the agile methodologies, is a process frame enabling the construction of the product incrementally by using the iterations that have fixed durations. Adapting the Scrum method to the mobile application developing process has been performed in the market where developing innovative mobile applications are important. The aim of this thesis is to achieve a mobile application needed in the field of clinical trials by using agile software developing methodology. In this context, a study was carried out about how to apply the Scrum method in the process of developing mobile application by detailing the concepts in the process of Scrum which is one of the agile software development methodologies. The points becoming prominent in this process such as how teams are created to start the project, how customer needs are determined, how changing customer demands are managed during the process and how transparency, inspection and adaptation are provided were detailed based on the concepts in Scrum process. Android-based mobile application developed in consequence of the thesis was published on Google Market.

Baytam (2011) made a study about that One of the frequently experienced problems in today’s software development environment is the changing customer requirements faced through the product development life cycle. Classic software development processes cannot adopt to these changes because of their structures and the way they advance, as a result, the projects often result in failure. Therefore, the usage of agile processes which brings a new philosophy and modernity compared to the classical processes is increasing rapidly in software projects, and project teams migrate to agile development processes. In this thesis, primarily, Scrum which is the most adapted

member of the agile processes models will be examined. The historical development of the process, its content and rules will be presented with related literature research. In the next section, the design and implementation of the process management system, which is the main idea of thesis, will be explained. Scrum application will be explained in details and the results will be interpreted.

Meixner(2011) focused on his study on the evaluation of a multi criteria decision problem by use of fuzzy logic. The methodological considerations concerning group decision are demonstrated and fuzziness on the basis of a specific problem is measured in this study: the search which is for energy alternatives and a proper evaluation of these alternatives. For the future, it is expected that this issue will be of increasing importance. They claimed the using a numerical example how the evaluation process could be improved by use of fuzzy logic and Saaty's analytic hierarchy process, to come close to reality and human cognitive behavior.

Butt, Liaqatand Khan (2013) did a study about identification a range of measures that can be used to assess the success of the common factors in the successful software projects in Pakistan software industry. The measures are identified based on literature and a survey conducted in the software professionals. The consideration of a development process model and an analysis of the opinions of the professionals are elaborated in context Pakistan's software industry. In this study, the guidelines for the project managers regarding perceptions from software practitioners are concluded. Extensive Survey results and Tables elaborated the common factors in the Successful Software Projects.

Derindere(2013) advocated that in order to transfer the knowledge gained in highly complex industrial environments to software development projects, the paradigm of project and underlying theory of agile software project management is examined and complex adaptive systems theory is proposed as a theory for software development. The adaptation of project and process management methods used in separate industries to software development is investigated using this theoretical foundation. Adaptation and different applications of these methods under different situations to software

development projects was examined. Keywords: Software Project Management, Agile Software Development, Project Management, Complex Adaptive Systems, Lean, Kanban, Theory of Constraints

Nasir and Sahibuddin (2011) prepared a comparative study and presented a literature survey of critical success factors that impact software projects. Forty-three articles from the years 1990 to 2010 were analyzed to develop a list of critical factors that specifically affect the success of software projects. The method of content analysis and frequency analysis was adopted. Twenty-six critical success factors were found to be related to software project success. The study suggested that organization or project manager is attentive to control the top five critical factors to drive towards project success since the percentage of frequency of occurrences for each is more than 50 percent.

Wan and Wang (2010) mentioned the key success factors for agile methods software development, it mentioned that most critical success factors depend on the point of view of the project manager so it advised the project managers to pick the success factors that will bring more return on investment and implement them.

Cockburn and Highsmith (2001) were talking specifically about the people factors in software development and how this factor can lead to the success of the project.

Abdulaziz and Mayhew (2013) presented a case study of the main factors that affect IT projects success in Saudi Arabian public organizations. A two-phase approach has been adopted combining qualitative and quantitative research methods. Phase 1, performed a qualitative approach using semi-structured interview method was used to collect and analyze the data, and the findings of this phase proposed seventeen factors. Then, in phase 2, a quantitative approach using questionnaire method was used to assess and validate the outcomes of phase I. The results of the questionnaire confirmed the importance of those seventeen factors, and the critical success factors of IT projects in Saudi Arabian public organizations to be found are: project management, project team competency, communication management, top management support and commitment,

strategic planning, training and education, partners and suppliers management, and stakeholders management.

Oferi (2013) aimed to identify and assess the critical success factors for projects in Ghana, The study is an exploratory approach, utilized a survey method to collect data on project management practices of Ghanaian organizations. Results of the study indicated that the critical factors that contribute to the questionnaire and applied knowledge creation theory to analyze the open source software community to find the critical success factors of agile software projects improvements.

Nasir and Sahibuddin(2011) said for their thesis, Although there have been studies completed on the critical success factors of software projects, these studies all have been specific to one particular country. There has been no comprehensive study reporting on different project sizes in various domains and in multiple countries. They present their extensive literature survey of critical success factors that impact software projects. Forty-three articles from the years 1990 to 2010 were found to be significant contributions that could be analyzed in order to develop a list of critical factors that specifically affect the success of software projects. The method of content analysis and frequency analysis was adopted. Twenty-six critical success factors were found to be related to software project success.
They suggest that organization or project manager is attentive to control the top five critical factors to drive towards project success since the percentage of frequency of occurrences for each is more than 50 percent. Also, it appears that non-technical factors (94 percent) dominated over technical factors (6 percent). In a result unique to their study compared with previous one, they found that the factors of clear and frozen requirements, realistic estimation of the schedule and budget, along with a competent project manager are the five most critical success factors of software projects.

Chaw and Cao (1981) performed quantitative survey among Agile professionals, gathering survey data from 109 Agile projects from 25 countries across the world. Multiple regression techniques were used, both at the full regression model and at the

optimized regression model via the stepwise screening procedure. The results showed that only 10 out of 48 hypotheses were supported.

2.3 DEFINITION OF SUCCESS CRITERIONS

Based on the literature list, Success Criterions are divided five main categories as Organizational, People, Process, Technical and Project. Each of main categories consists of sub-criterions which are consisted of detail criterions.

While detail criterions are being prepared, each is matched to at least one of Agile Manifesto Principles. Below, each table, which is written under its own sub-criterion and main criterion, shows which detail criterion is based on which Agile Manifesto Principles.

2.3.1 Organizational Factors

Organization categories consist of three sub criterions which are Management Commitment, Organizational Environment and Team Distribution as shown Table 2.1.

Table 2.1: Organizational success criterions

	ORGANIZATIONAL		
K1	K11	**Management Commitment**	
		K1101	Strong executive support
		K1102	Committed sponsor or manager
	K12	**Organizational Environment**	
		K1201	Cooperative organizational culture instead of hierarchal
		K1202	Organizations where agile methodology is universally accepted
		K1203	Oral culture placing high value on face-to-face communication
		K1204	Facility with proper agile-style work environment

	K13	**Team Distribution**	
		K1301	Collocation of the whole team
		K1302	Team size being too large

At this category, eight detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles.

2.3.1.1 Management commitment

This sub criterion includes two detail criterions and Table 2.2 shows matching management commitment with principles which are expressed on agile manifesto.

Table 2.2: Matches of management commiment and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Strong executive support	4, 11
Committed sponsor or manager	11

2.3.1.2 Organizational environment

This sub criterion includes two detail criterions and Table 2.3 shows matching organizational environment with principles which are expressed on agile manifesto.

Table 2.3: Matches of organizational environment and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Cooperative organizational culture instead of hierarchal	4, 11
Organizations where agile methodology is universally accepted	11
Oral culture placing high value on face-to-face communication	4, 6
Facility with proper agile-style work environment	11

2.3.1.3 Team distribution

This sub criterion includes two detail criterions and Table 2.4 shows matching team distribution with principles which are expressed on agile manifesto.

Table 2.4: Matches of team distribution and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Collocation of the whole team	6, 12
Team size being too large	8, 12,11

2.3.2 People Factors

People category consists of two sub-criterions which are Knowlegde and experience, Team Behaviour as shown Table 2.5.

Table 2.5: People success criterions

	PEOPLE		
K2	K21	***Knowledge and Experience***	
		K2101	Team members with high competence and expertise
		K2102	Managers knowledgeable in agile process Good customer relationship
		K2103	Good customer relationship
	K22	***Team behavior***	
		K2201	Team members with great motivation
		K2202	Coherent, self-organizing teamwork
		K2203	Managers who have light-touch or adaptive management style

At this category, six detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles.

2.3.2.1 Knowledge and experience

This sub criterion includes three detail criterions and Table 2.6 shows matching knowledge and experience with principles which are expressed on agile manifesto.

Table 2.6: Matches of knowledge-experience and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Team members with high competence and expertise	4, 5
Managers knowledgeable in agile process Good customer relationship	4
Good customer relationship	1, 2

2.3.2.2 Team behaviour

This sub criterion includes three detail criterions and Table 2.7 shows matching team behaviour with principles which are expressed on agile manifesto.

Table 2.7: Matches of team behaviour and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Team members with great motivation	5
Coherent, self-organizing teamwork	11
Managers who have light-touch or adaptive management style	11

2.3.3 Technical Factors

Technical category consists of a sub-criterion which is technology and Tools as shown Table 2.8.

Table 2.8: Technical success criterions

	TECHNICAL		
K4	K41	***Technology and Tools***	
		K4101	Well-defined coding standards up front
		K4102	Pursuing simple design
		K4103	Rigorous refactoring activities
		K4104	Right amount of documentation
		K4105	Regular delivery of software
		K4106	Delivering most important features first
		K4107	Correct integration testing
		K4108	Appropriate technical training to team
		K4109	Accurate sizing/design estimate

At this category, nine detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles.

2.3.3.1 Technology and tools

This sub criterion includes nine detail criterions and Table 2.9 shows matching technology and tools with principles which are expressed on agile manifesto.

Table 2.9: Matches of technology-tools and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Well-defined coding standards up front	9, 11
Pursuing simple design	10
Rigorous refactoring activities	10, 12

Right amount of documentation	1
Regular delivery of software	3, 8
Delivering most important features first	11
Correct integration testing	1, 7
Appropriate technical training to team	4
Accurate sizing/design estimate	12

2.3.4 Process Factors

Process category consists of three sub-criterions which are requirement and planning, customer role and tracking tools as shown Table 2.10.

Table 2.10: Process success criterions

	PROCESS		
K3	K31	***Requirements and Planning***	
		K3101	Clear and well understood project scope and requirements
		K3102	Accurate project planning
	K32	***Customer Role***	
		K3201	Strong customer commitment and presence
		K3202	Customer having full authority
	K33	***Tracking Tools***	
		K3301	Following agile-oriented requirement management process
		K3302	Following agile-oriented project management process

At this category, six detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles.

2.3.4.1 Requirement and planning

This sub criterion includes two detail criterions and Table 2.11 shows matching requirement and planning with principles which are expressed on agile manifesto.

Table 2.11: Matches of requirement-planning and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Clear and well understood project scope and requirements	1, 2
Accurate project planning	2

2.3.4.2 Customer role

This sub criterion includes two detail criterions and Table 2.12 shows matching customer role with principles which are expressed on agile manifesto.

Table 2.12: Matches of customer role and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Strong customer commitment and presence	1, 2, 3
Customer having full authority	3

2.3.4.3 Tracking tools

This sub criterion includes two detail criterions and Table 2.13 shows matching tracking tools with principles which are expressed on agile manifesto.

Table 2.13: Matches of tracking tools and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Following agile-oriented requirement management process	1
Following agile-oriented project management process	2

2.3.5 Project Factors

Project category consists of a sub-criterion which is Project type as shown Table 2.14.

Table 2.14: Project success criterions

	PROJECT		
K5	K51	***Project Type***	
		K5101	Project type being of variable scope with emergent requirement
		K5102	Projects with small team
		K5103	Projects with no multiple independent teams
		K5104	Projects with up-front cost evaluation done

At this category, four detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles.

2.3.5.1 Project type

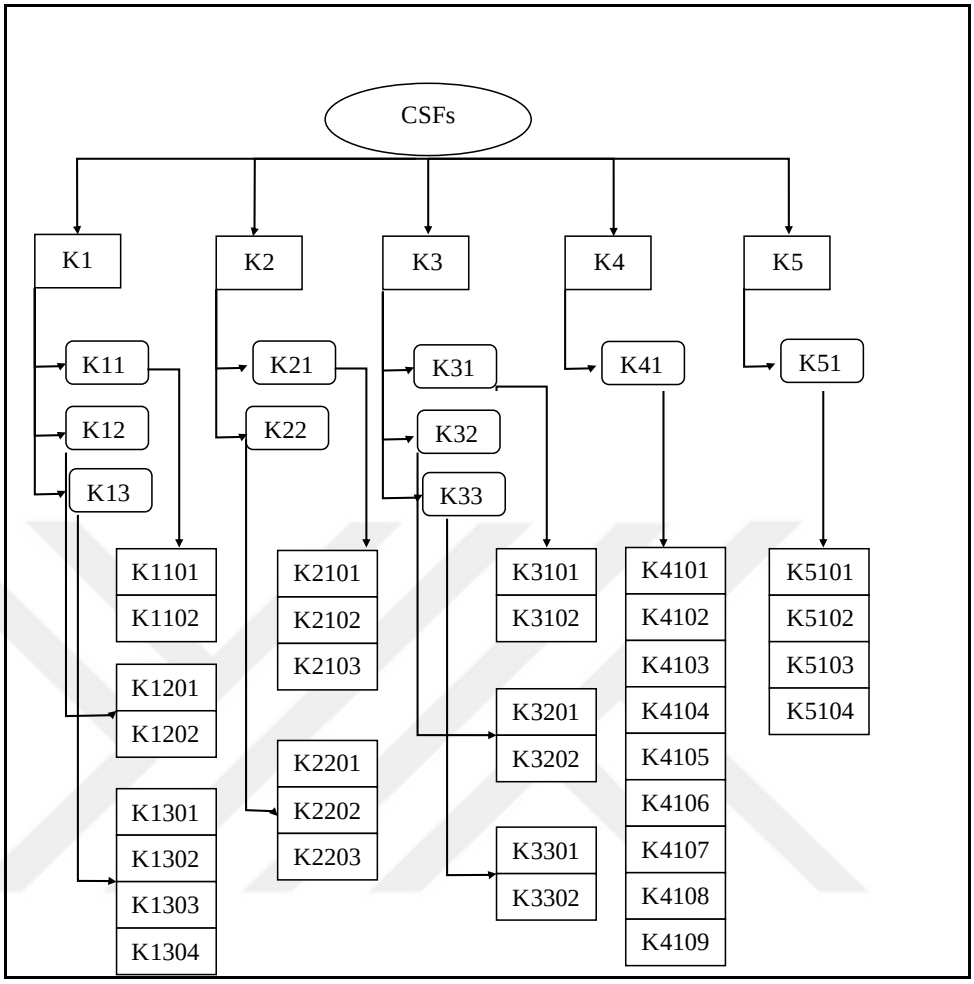
This sub criterion includes four detail criterions and Table 2.15 shows matching Project type with principles which are expressed on agile manifesto.

Table 2.15: Matches of Project type and agile manifesto

Detail Criterion	**Agile Manifesto Principles**
Project type being of variable scope with emergent requirement	7, 11
Projects with small team	4, 5, 11
Projects with no multiple independent teams	4
Projects with up-front cost evaluation done	2, 3

Thus, success criterion are expressed as hierarchical structure at Figure 2.1.

Figure 2.1: Hierarchical structure of success criterions



2.4 DEFINITION OF FAILURE CRITERIONS

Same as success criterions, Failure criterions are divided four main categories as Organizational, People, Process, Technical. Each of main category consists of sub-criterions which are consisted of detail criterions.

While detail criterions are being prepared, each is matched to at least one of Agile Manifesto Principles. But, match table was shown in previous section.

2.4.1 Organizational Factors

Organization categories consists of two sub criterions which are Management Commitment and Organizational Environment and Culture as shown Table 2.16.

Table 2.16: Organizational failure criterions

F1	**ORGANIZATIONAL**		
	F11	**Management Commitment**	
		F1101	Absence of executive sponsorship
		F1102	Absence of management support
	F12	**Organizational Environment and Culture**	
		F1201	Organization is multi-regional and too large
		F1202	Organizational principles excessively political
		F1203	Organizational culture traditional or outdated
		F1204	External pressure to follow traditional waterfall process
		F1205	Unsuitable facility/working environment
		F1206	Locally distributed teams instead of co-location
		F1207	Team sizes are too large

At this category, nine detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles shown at Table 2.2.

2.4.2 People Factors

People category consists of two sub-criterions which are Knowlegde and experience, Team Behaviour as shown Table 2.17.

Table 2.17: People failure criterions

F2	**PEOPLE**		
	F21	***Knowledge and Experience***	
		F2101	Insufficient experience

		F2102	Lack of the required skill set
		F2103	Insufficient project management proficiency
	F22	***Team behavior***	
		F2201	Absence of team work
		F2202	Resistance from teams or individuals
		F2203	Weak customer relationship
		F2204	Demotivation of team members/team

At this category, seven detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles shown at Table 2.6.

2.4.3 Technical Factors

Technical category consists of a sub-criterion which is technology and Tools as shown Table 2.18.

Table 2.18: Technical failure criterions

F3	**TECHNICAL**		
	F31	***Technology and Tools***	
		F3101	Unsuitable technology and tools
		F3102	Lack of code review/inspections
		F3103	Insufficient test cases/test coverage
		F3104	Lack of tester in the team (developer is the tester)
		F3105	Lack of technical or customer facing documentation
		F3106	Unrealistic/short design estimates
		F3107	Insufficient training
		F3108	Absence of developer involvement in prioritization
		F3109	Absence of risk analysis, lessons-learned (retrospective)

At this category, nine detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles shown at Table 2.9.

2.4.4 Process Factors

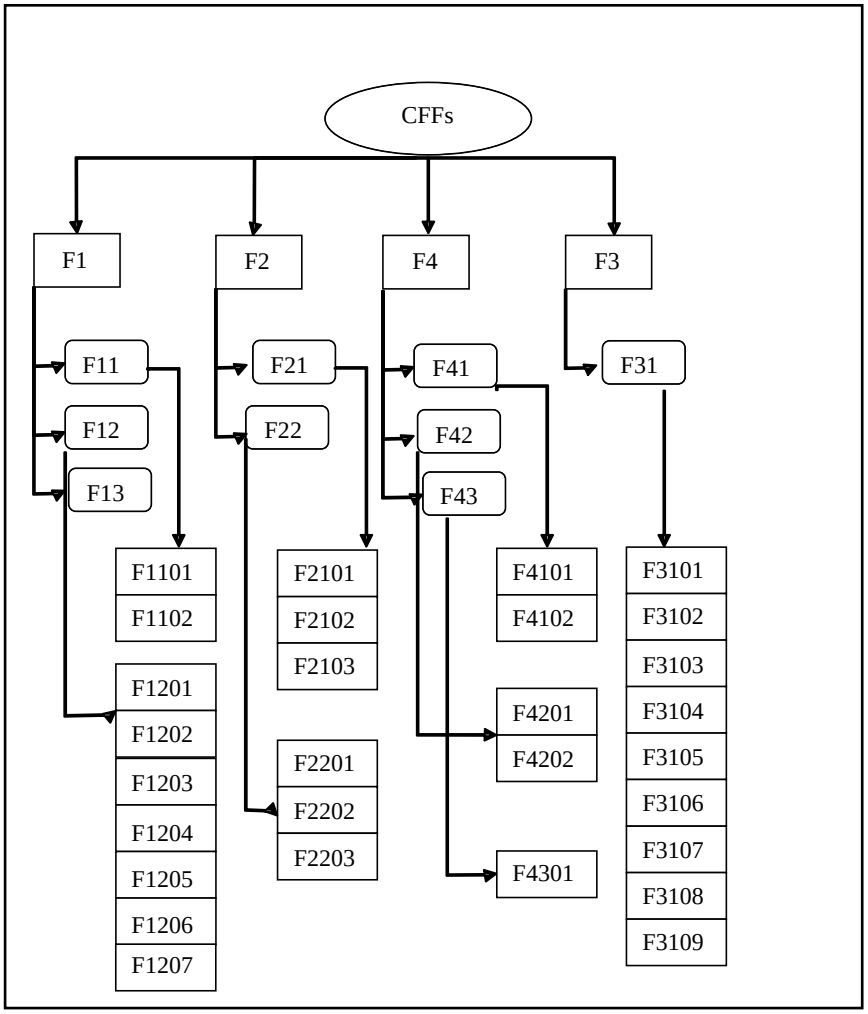
Process category consists of three sub-criterions which are requirement and planning, customer role and tracking tools as shown Table 2.19.

Table 2.19: Process success criterions

F4	**PROCESS**		
	F41	***Requirements and Planning***	
		F4101	Imprecise project scope and requirements
		F4102	Inaccurate project planning
	F42	***Customer Role***	
		F4201	Vague customer role
		F4202	Absence of customer presence
	F43	***Tracking Tools***	
		F4301	Absence of agile progress tracking methods/systems

At this category, six detail criterions are defined and each criterions are matched to at least one of Agile Manifesto Principles shown at Table 2.11, Table 2.12 and Table 2.13.

Figure 2.2: Hierarchical structure of failure criterions



3. DATA AND METHODS

3.1 DATA SET

In this thesis study, as similar previous studies, a survey was used in order to gather data. The survey consists of two main parts. The purpose of first part is getting information about engineer's total experience, agile experience, opinions about technical aspect of own team members. For this first part makes of fifteen questions.

The purpose of second part is measuring how much Agile methodologies are being applied at software companies. In this part, all questions were prepared as positive and negative statement according to Agile Manifesto.

"*New requirement from customer should be accepted any phase of a project* "

This is an example for positive statement. Because Agile Manifest advocates this principle.

"*Before starting Project, an Immutable plan should be prepared and it should not be changed later*"

This is an example for negative statement. Because Agile Manifest traverses this principle.

It is expected that if a software engineer knows Agile very well and applies it properly at his company, He will give positive answer for positive statements and negative answer for negative statements

Also as an answer, five-likert tecnique was selected as shown Table 3.1.

Table 3.1: Five-Likert Tecnique

Absolutely Agree
Agree
Neither Agree nor Disagree
Disagree
Absolutely Disagree

As a result, after gathering all data thanks to the survey, 18 engineers's data will be selected based on agile experience. And also these18 survey responders are in different roles such as project manager, software architects, scrum masters and scrum designers.

The final proses is creation data set from selected 18 expert responder's answers. Firstly, All answers are examined one by one.

a. For the positive statements, all answers are turned to numeric value according to table which is below

Table 3.2: Numeric value of answers for positive statement

Absolutely Agree	5
Agree	4
Neither Agree nor Disagree	3
Disagree	2
Absolutely Disagree	1

b. For the negative statements, all answers are turned to numeric value according to table which is below

Table 3.3: Numeric value of answers for negative statement

Absolutely Agree	1
Agree	2
Neither Agree nor Disagree	3
Disagree	4

Absolutely Disagree	5

After that, Fuzzy AHP will be applied on data set which turned to numeric value belonging to 18 most agile experient engineer in order to make priorization on criterions.

3.2 METHODS

3.2.1 Fuzzy Logic

A case which result is exactly unknown or which is able to be understood differently by different person or which have subjectif datas is called as “uncertanity”.

All people met lots of uncertanity case in their life. For example, at home, at school, at street, anywhere the people can reach. A person who would like to buy something new has a lot of questions in his mind, what size, what color, Which one is the best, which one is the comfortable etc. Therefore, it is so difficult to handle these kind of uncertanity case by using classic logic, it can be even impossible.

In the academic world, uncertanity is named as fuzzy, and to solve uncertanity case, fuzzy logic was developed. In classic logic, a case is either true or false. On the other hand, there are some situation between true and false in fuzzy logic.

In the world where the complexity and uncertanity case increased, the people improved computers in order to bring fast solution for these case. But this computers could not help (Tekeş 2002, s. 86). In 1965, Prof.Lotfi A. Zadeh, who is ciziten of Azerbaijani, developped fuzzy sets to express uncertanity(Çitli 2006 s. 3).
In Fuzzy Logic, apart from white and black, there are different colors between them. This kind of system is very close to human thinking system.

Mathematics always uses the objects which are good defined when it interacts with classic logic sets. Here, what a good defined object is that same thinking arises for

different people. At Mathematics, if old and young people sets are handled, the concurrence sets of these two sets is empty. If 50 years old people are called as old, and 20 years old people are called as young, there is nothing to say for people who are 30 years old. They are neither old nor young at classic logic. On the other hand, whatever years old person can find a set for itself in fuzzy logic.

Basis difference between Classic logic and Fuzzy logic is given below.

Table 3.4: Comparison Classic and Fuzzy Logic

Classic Logic	**Fuzzy Logic**
Certain	Uncertain
Only All or Any	Definitions between All and Any
0 or 1	Between 0 and 1
Binary units	Fuzzy units
A or not A	A and not A

Source: Yaralıoglu, K, t.y: 1

3.2.1.1 Advantages and disadvantages of fuzzy logic

The best advantages of fuzzy logic is that learning by human experience can be modeled easily and even uncertain case can be expressed mathematically (FL 2007 s. 6). Other advantages are:

a. Close to human thinking system
b. Cheaper for easy implementation
c. Easy to apply
d. Use for some problems which have lack of definition
e. Less dependency to mathematical modelling

Disadvantages of fuzzy logic are;

a. The rules which will be used depend on experience

b. No rulet o define membership function and to use trial and error way to find membership function
c. All can be done is assimilation works. Stability analaysis could not do.

3.2.2 Fuzzy Sets

In classical set logic, an element is wholly owned by the set or it is not belonging to the set. For example lets consider A = {a, b, c}. Here "a is belonging to the set" means 'a' is a member of the set; but 'd' is not an element of the set. Here we can express the "degree of membership" to be the member of the set.

The membership degree illustrates to be, not to be or how to be belonging to the set. In classical set logic, the degree of elements belonging to the set as membership degree is expressed with 1, the degree of expression which is not belonging to the set members is expressed 0. In this fuzzy set logic the degree of membership is shown with [0,1] closed value range.

The biggest set that covers all sets that are under process is called as the universal set. A fuzzy set is described as assigning a membership degree for each element of the universal set (Tekes 2002 s. 88).

Fuzzy sets can be expressed mathematically as follows: Assigning a value of membership degree in the fuzzy set to any element within the Universal set. The mentioned membership degree represents the compliance degree of fuzzy set characteristics of the element. In this case, there is no distinction like element certainly belongs to the set or not (Karadogan 2001 s. 96).

Fuzzy set is defined as membership function, where membership degree expressed with a real number in the [0,1] closed range set (Chang 2008 s. 339)

Normal fuzzy sets are the sets which an element of membership degree is 1. The fuzzy sets that are not complying with this case are called abnormal fuzzy sets (Alkan 2006 s. 37).

A fuzzy set is called a convex fuzzy set, if the membership degree is monotonously increasing until value 1 then monotonously decreasing (Alkan 2006 s. 38).

3.2.2.1 Membership functions

The membership degree is defined as an element's degree of belonging to the set. In classical set logic, if an element that belongs to set, that element gets the value of 1, otherwise 0.

For example let's consider overweighed people set:
Lets define the set like this A={x} x:The people who weight more than 100kg. μ(x) shows the membership function for this set.

According to that the membership function of this set:

$$\mu_A(x) = \begin{cases} 1 & , x > 100kg \\ 0 & , others \end{cases} \quad \textbf{(3.1)}$$

In the classic sets, someone who is 99 kg will not be considered as overweighed thus the membership degree of this person is 0. But in the fuzzy sets, this person is considered as overweighed in some degree and he can be assigned to a membership degree. In fuzzy sets we can state this with the membership function.

$$\mu_A(x) = \begin{cases} 1 & , x > 100 & kg \\ \dfrac{x-90}{10} & , 90 \le x \le 100 & kg \\ 0 & , x < 90 & kg \end{cases} \quad \textbf{(3.2)}$$

According to the definition of this function, people who are between 90 - 100 kg are accepted as overweighed to some degree. In this case, a 100 kg person has the membership degree of 1, while a 99kg person has the membership degree 0.9 and the man with 95kg person has the membership degree 0.5

Accordingly, the fuzzy sets are based on membership functions and operations are performed using these functions. In the literature, membership functions are defined in several different ways (Yenilmez 2001 s. 12).

a. A two-parameter increasing membership function
b. A two-parameter declining membership function
c. The three-parameter increasing membership function
d. Triangular (Triangular) membership function
e. Trapezoid (trapezoidal) membership function
f. The bell-shaped membership function

In this study, since triangular membership function will be used therefore only triangular membership functions detailed.

3.2.2.1.1 Triangular membership function

Triangular membership functions are the functions whose elements are defined as A = (m, n, u). Here ‘n’ holds the most probable value while ‘m’ holds the smallest value or the lower limit and ‘u’ represents the largest value or the upper limit.

$$\mu_A(x) = \begin{cases} 0 & , x < m \\ \dfrac{x-m}{n-m} & , m \le x \le n \\ \dfrac{u-x}{u-n} & , n \le x \le u \\ 0 & , x > u \end{cases} \qquad \textbf{(3.3)}$$

3.2.3 Fuzzy Numbers

Fuzzy numbers can be defined as a function which maps each real number with a closed range [0,1] . Fuzzy numbers are a fuzzy subset of real numbers and shows advanced form of "Confidence Intervals." (Kaptanoglu Özokur 2006 s. 197).

According to Bali (2004), "Fuzzy numbers are a set of fuzzy numbers which is normal and convex feature characterized. In this instance, to be member of a fuzzy numbers , ıt must be characterized by normal and convex feature" (Bali 2004 s. 33).

As the non-fuzzy sets, non-fuzzy numbers are defined a single point and degree of membership of non-fuzzy numbers are 0 or 1. A fuzzy number is defined at least within a range and gets any value which is in membership degree [0.1]. So fuzzy number has no exact value, but it can be known its value and degree of membership of these values.

Fuzzy numbers are basically defined as a range. According to the value which is in the range, fuzzy numbers get different name. For example; (5.11) Fuzzy number, (5,8,11) Triangular Fuzzy Number, (5,7,9,11) Trapezoid Fuzzy Numbers ,etc.

Fuzzy numbers are defined as Triangular fuzzy number, Trapezoid Fuzzy Numbers, Bell-shaped Fuzzy Numbers and etc. In this study,Triangular Fuzzy Numbers were used.

3.2.3.1 Triangular fuzzy numbers

Triangular fuzzy numbers are considered as real numbers in sequential triple. But the difference between fuzzy numbers and real numbers in sequential triple are written from small to large. Triangular fuzzy numbers consist three components.

The first component of these components shows the lower value, middle component shows optimum value and third component shows the upper value. 2 neighborhood of

3 in Mathematics are taken : (1,3,5) . Triangular fuzzy numbers are considered as the neighborhood of a number.But ın this case, the most propable value in Triangular fuzzy numbers is equidistant to lower and upper value, where as that is not required to be equidistant.

If, $\mu_A(x): \Re \to [0,1]$, Triangular fuzzy numbers expressed as $A = (m_1, \quad n_1, \quad u_1)$ (Yong, D, 2006: 840).

3.2.3.1.1 Transactions on triangular fuzzy numbers

If $m_1 \le n_1 \le u_1$, $m_2 \le n_2 \le u_2$, Fuzzy numbers are defined as $A = (m_1, \quad n_1, \quad u_1)$ and $B = (m_2, \quad n_2, \quad u_2)$ (Ertugrul, I and Nakkasoglu, N 2006 s. 197).

a. Addition operations

Addition operations is done as if sequential triple Addition operations .
First component is added to first component, second component is added to second component, third component is added to third component,

$$A + B = (m_1 + m_2, \quad n_1 + n_2, \quad u_1 + u_2) \qquad \textbf{(3.4)}$$

b. Subtraction operations

Subtraction operations is done as if sequential triple Subtraction operations . Third component is removed from first component, Second component is is removed from second component, first component is removed from the third component.

$$A - B = (m_1 - u_2, \quad n_1 - n_2, \quad u_1 - m_2) \qquad \textbf{(3.5)}$$

c. Multiplication operations

$$AxB = (m_1.m_2, \quad n_1.n_2, \quad u_1.u_2) \tag{3.6}$$

d. Division operations

If A and B is positive

$$\frac{A}{B} = \left(\frac{m_1}{u_2}, \quad \frac{n_1}{n_2}, \quad \frac{u_1}{m_2}\right) \tag{3.7}$$

If A and B is negative

$$\frac{A}{B} = \left(\frac{m_1}{m_2}, \quad \frac{n_1}{n_2}, \quad \frac{u_1}{u_2}\right) \tag{3.8}$$

e. Inverse of Triangular Fuzzy Number

$$A^{-1} = \left(\frac{1}{u_1}, \quad \frac{1}{n_1}, \quad \frac{1}{m_1}\right) \tag{3.9}$$

3.2.4 Analytical Hierarchy Process (AHP)

AHP which had been confessed by L. Thomas Saaty in 1965 was used in ABD department of defense in 1971 in order to plan possibility problems. After that usage, it was used at various departments and by being used for Sudan transportation Project, it was decided that AHP proved its reliability Finally AHP completed its improving process at between 1974 and 1978 (Ayyıldız 2003 s. 110)

AHP, while chosing something or making priority between lots of alternatives, is used in case of that there are more decision-makers, more criterions, more goals, either certanity or uncertanity case (Yılmaz 2000 s. 13).

From first day in the human life to now, people would make decision instinctively if they attain with any problem. At these kind of decisions (instinctively) also can be decided for abstract concepts. A decision which is taken by instinctively changes human by human due to depend on personality. That is the reason abstract concepts that is so difficult for some approaches can be handle by AHP.(Gungor and Isler 2005 s. 22)

AHP is an approach that, besides concrete criterions, can be able to handle abstract criterions. AHP is a decision making technique, which measures all criterions by doing pairwise comparisons and defines priority for each of all criterions (Byun 2001 s. 290). on pairwise comparison, decide that either which one of the pair important is or which one is preferred over other. AHP helps executive for being flexible and easily usage (Guner 2005 s.18). Knowlegde and experience is as important as data which will be used.

AHP is one of the method which is used for decision making. Firstly, define the problem and criterons, sub criterions and alternatives which belongs to the problem. In this point, a hierarchy will be created. Now, it is time to prepare pairwise comparison matrix and find weight vector. Finally, the best order arises.

3.2.4.1 AHP recognized truths

Four recognized truths are composite of basic of AHP (Yilmaz 2000 s. 22).

a. **Recognized Truth**: (Reciprocal Comperation) According to this truth, if truth X is k times more important than truth Y, truth Y is 1/k times more important than truth. i.e, if criterion X is 3 times more important than criterion Y, criterion Y is 0,33 times more important than criterion X.

b. **Recognized Truth:** (Homogenalty) if criterion X and criterion Y are being wanted to be compared each other, there should not be much difference between them.

c. **Recognized Truth:** (Expectations) All criterions and alternatives must take part on hierarchy in order to answer to all expectations. So, all criterions must be related to same aim.

d. **Recognized Truth:** (Independence) the all options and all criterions which are compared must be independence from each other.

3.2.4.2 AHP solution steps

The problem is detected and a target which is top of the hierarchy is defined.

a. A hierarchy is created. In this hierarchy, all criterions, sub criterions and detail criterions are defined.
b. Pairwise comparison matrix is created.
c. Weight vector is prepared by using pairwise comparison matrix.
d. Consistency values are calculated for each comperations. it is decided whether consistency is ok or not. If not, pairwise comparisons are re-prepared and process is repeated.

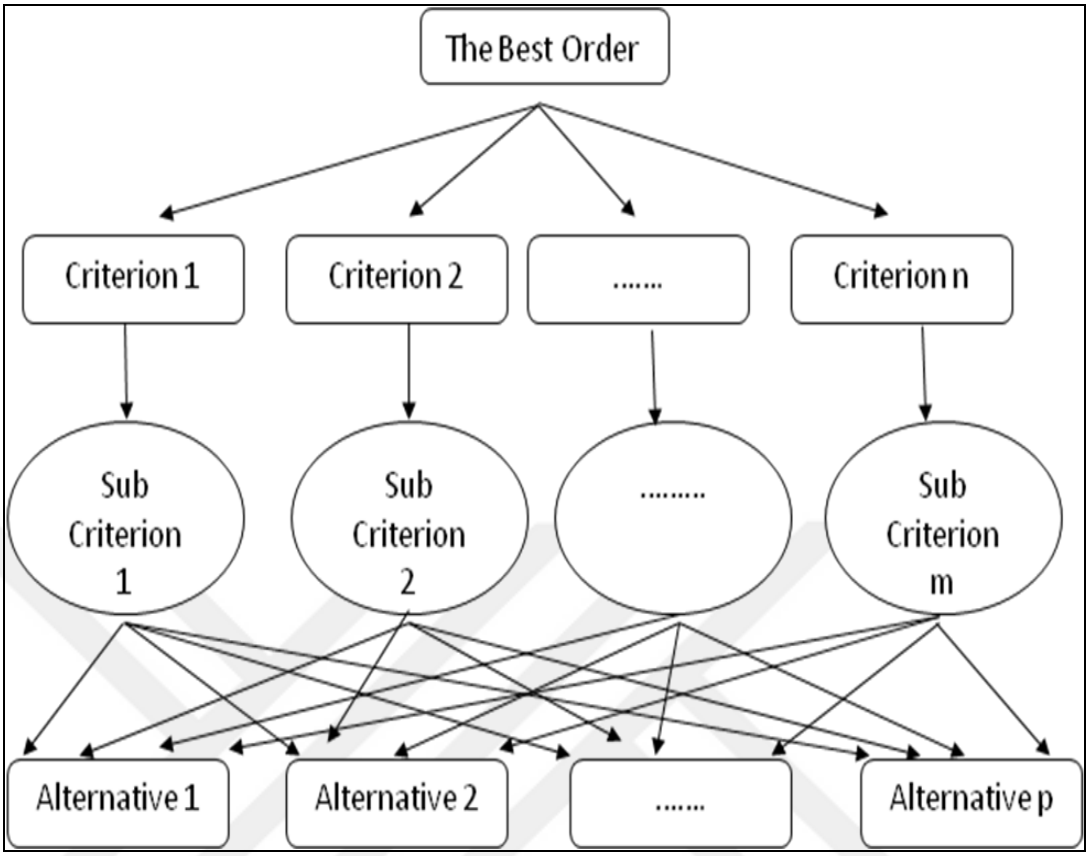
3.2.4.3 Hierarchy creation

Hierarchy, while it is went up to its top,
According to Hacımenni (1998 s. 22): “Hierarchy organizes all related factors and helps solving problems with logical and systematic way all related factors”

Generally, Hierarchy makes of four steps. These steps are (up to down):

1. The problem which will be decided
2. Main criterions
3. Sub criterions
4. Alternatives

Figure 3.1: Hierarchy Model



Hierarchy model can be shown different way. Hierarchy models can be defined either completed hierarchy or uncompleted hierarchy.

Completed hierarchy model : in case of that a sub-criterion affects all criterions which are above. Uncompleted hierarchy model: in case of that a sub-criterion does not affect all criterions which are above (Yetim 2003 s. 32).

The aim which locates top of the hierarchy should have more criterions, sub-criterions and alternatives, takes both objectif decisions and subjectif decisions,

3.2.4.4 Buckley approach

Buckley improved AHP method which belongs to Saaty by using fuzzy comparison ratio (a_{ij}) in 1985. Buckley drew attantion to two problems on method of Van Laarhoven and Peddrycz (Göksu 2008). First problem is the linear equations which are used on method of Van Laarhoven and Peddrycz does not have single solution, second

problem is these equations absolutely need using exponential fuzzy numbers (Göksu 2008).

Buckley solved this problems and calculated performance points by using geometric mean. In this case, only one solution is assured for pairwise comparison (Göksu 2008).

The disadvantage of Buckley approach is to have much calculations(Göksu 2008).

A positive pairwise comparison matrix is shown below.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad \textbf{(3.10)}$$

Geometric mean for each row is calculated.

$$z_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}} \qquad i, j = 1,2,3,\ldots\ldots,n \quad \textbf{(3.11)}$$

Weight vector is also calculated as below

$$w_i = \frac{z_i}{z_1 + z_1 + \ldots + z_n}, \forall i \quad \textbf{(3.12)}$$

3.2.4.5 Pairwise comparison

If n criterions are wanted to be compared by using pairwise comparison, The count of comparisons should be calculated with this Formula.

$$C(n,2) = \frac{n!}{(n-2)!.2!}, (n \geq 2) \qquad \textbf{(3.13)}$$

In case to arrange, this Formula $\frac{n.(n-1)}{2}$ occurs.

Assume that in Pairwise comparison matrix, there are n criterions like $C_1, C_2, ..., C_n$. $C = (a_{ij}),\ ij = 1,2,3.....,n$, continue assuming that a matrix which size is nxn, weight degrees are W_1, W_2, …. W_n the item (a_{ij}) of this matrix must have two features (Saaty and Ozdemir 2003 s. 236).

If $a_{ij} = k$, so a_{ji} must be $\frac{1}{k}, (k \neq 0)$

If W_1 is as important as W_2, so both a_{ij} and a_{ji} must be 1.

With these feature, a matrix must be like that:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{1}{a_{n1}} & \frac{1}{a_{n2}} & \cdots & 1 \end{bmatrix} \qquad \textbf{(3.14)}$$

Here $a_{ij} = \frac{W_i}{W_j}$ means importance of C_i criterion in case of comparison with C_j criterion. For example $W_i = 27$, $W_j = 9$ so $a_{ij} = 3$ so 3 means, C_i criterion is three times more important than C_j criterion.

$$A = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_n \end{array} \begin{array}{c} \begin{array}{cccc} A_1 & A_2 & \cdots & A_n \end{array} \\ \begin{bmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \frac{w_2}{w_1} & \frac{w_2}{w_2} & \cdots & \frac{w_2}{w_n} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{bmatrix} \end{array} \quad \textbf{(3.15)}$$

While creating pairwise comparison matrix, a scale which is between from 1 to 15 is used. But generally 1-9 scale is preferred. This 1-9 scale was defined by Saaty for using on AHP as shown Table 3.4. (Saaty vd 2003 s. 174).

Table 3.5: Saaty AHP statements

Significance Degree a_{ij}	**Definition**
1	One is as important as other
3	One is a bit important than other
5	One is a bit more important than other
7	One is more important than other
9	One is much more important than other
2,5,6,8	Average values

Source: Saaty,vd., 2003: 174

3.2.4.5.1 Calculation on pairwise comparison

Four method was developed in order to calculate values on pairwise comparison, (Ayyıldız 2003 s. 123)

a. **Coarsest Method**

a. All values which are at the same row are sum. (row sum)
b. Sum all sum of each row (total sum)
c. Divide each row sum to total sum (row result)
d. All raw results total would equal to 1 by doing normalization
e. As a result a vector would be created and first item of this vector is weight of first criterion and second item is weight of second criterion

b. **Better Method**

a. All values which are at the same coloum are sum and find conjugate. (coloum conjugate)
b. Sum all coloum conjugate (total conjugate)
c. Each coloum conjugate is divided to total conjugate

c. **Good by division Method**

a. Each column elements are divided to sum of same coloum's elements.(column result)
b. Sum of row result is calculated by using column result (row sum)
c. Row sum is divided by element count of same row.

d. **Good by multiplication Method:**

a. All values which are at the same row are gotton geometric mean (row result)
b. Each row result is made normalization

Finally, Consistency ratio is calculated by using one of these methods and according to this ratio, it is decided that pairwise comparison is consistent or not.

3.2.4.6 Consistency

Consistency can be defined mathematical and logical relationship between values which is found as a result of pairwise comparison.

After weight vector are found, consisstency ratio is calculated to find out whether values are consistent or not. To do this process, these steps are made successively.

a. Create a new vector by multiplying weight vector by pairwise comparison matrix.
b. The first element of this new vector is divided by the first element of weight vector and. The second element of this new vector is divided by the second element of weight vector. The nth element of this new vector is divided by the nth element of weight vector.
c. A new vector is created by doing division process which was mentioned previous step.
d. Sum all elements of this new vector which was created on previous step and divided sum value by count of elements.
e. The biggest eigen value(landamax) is approximately calculated as a result of previous step.
f. The closer the biggest eigen value and count of elements each other, the more consistent the result is achieved. (Tekeş 2002 s. 78)
g. After the biggest eigen value is found, to calculated consistency ratio, consistency indicator is divided by incidental indicator. If the result is less than 0.10, it can be said that all calculations are consistent.

$$\text{Consistency indicator} = \frac{\lambda_{\max} - n}{n-1} \quad \textbf{(3.16)}$$

$$\text{Consistency ratio} = \frac{\text{Consistency Indicator}}{\text{Coincidental Indicator}} \quad \textbf{(3.17)}$$

In case of found result is more than 0.10, pairwise comparison values are controlled and calculations are done again.

Table 3.6: Coincidental Indicators by Saaty

Matrix Dimention	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Coincidental Indicator	0	0	0,52	0,89	1,11	1,25	1,35	1,40	1,45	1,49	1,52	1,54	1,56	1,58	1,59

Source: Saaty and Tran, 2007:966

3.2.4.7 AHP advantages and disadvantages

All used method is not excellent, all methods have some advantages as it has some disadvantages. The important point is a method's advantages must be more than its disadvantages. Analytical hierarchy process also have some pros and cons (Kuruüzüm and Atsan 2001 s. 93).

Analytical hierarchy process disadvantages:

a. When an alternative is wanted to be added or to be removed, hierarchy order is changing.
b. Exact result is not achieved because of using also subjectif data
c. When criterion count or alternative count is increased, calculation count is also increased and getting more difficult.

Analytical hierarchy process advantages:

a. The most complex problems can be turned to more easily
b. Easy to be applied
c. For a decision problem, both objectif and subjectif data can be used.
d. Consistency ratio can be calculated and measured.
e. Can be applied for group decision.

4. FINDINGS

4.1 FINDINGS FOR SUCCESS CRITERIONS

In this chapter, what studies were done will be explained step by step. At the beginning of Section 3, it was mentioned that Agile Methodology was examined in five main categories.

a. Organizational
b. People
c. Process
d. Technical
e. Project

Data set was arranged as told section 3.1. and geometric mean was calculated for detail criterions belonging to each category by using Buckley approach.

$$z_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}} \quad \textbf{(4.1)}$$

4.1.1 Results Of Aspect Of Organizational Success Factors

For each organizational detail criterions, Geometric mean is calculated with 18 agile expert responder's answers which were given for organizational related questions as shown Table 4.1.

Table 4.1: Answers of responders related to organizational criterions

	Eng.1	Eng.2	Eng.3	Eng.4	Eng.5	Eng.6	Eng.7	Eng.8	Eng.9	Eng.10	Eng.11	Eng.12	Eng.13	Eng.14	Eng.15	Eng.16	Eng.17	Eng.18	**Geoeann**
K1101	2	4	1	4	5	2	4	5	3	5	2	2	4	4	2	3	3	3	2,974
K1102	2	5	2	2	2	5	2	2	5	2	2	1	1	1	3	2	5	1	2,149
K1201	1	5	5	1	1	5	1	1	5	1	5	1	5	1	5	1	3	1	1,987

K1202	5	1	5	1	1	5	5	1	5	5	5	5	1	5	5	1	1	1	2,445
K1203	1	5	5	1	1	5	1	1	5	1	1	1	1	5	5	1	3	1	1,817
K1204	5	1	5	1	1	5	1	1	5	3	4	1	1	5	5	1	1	1	1,963
K1301	3	1	3	2	1	5	5	1	1	1	1	1	1	3	1	3	1	3	1,686
K1302	5	3	5	1	1	5	5	5	1	5	1	1	1	1	5	5	1	5	2,376

After calculation geometric mean, all detail criterions' percentage weight is calculated.

$$Criterion_{Percentage Value} = \frac{Total_{geometric Mean}}{Criterion_{geometric Mean}}.100 \quad \textbf{(4.2)}$$

According to above Formula, all results are shown in Table 4.2.

Table 4.2: Geometric mean success criterions in organizational category

Organizational Criterions	**Geometric Mean**	**Percentage Values**
K1101	2,97426921	17,09313046
K1102	2,14955421	12,35349186
K1201	1,98759733	11,42272539
K1202	2,44521285	14,05264259
K1203	1,8175934	10,44571252
K1204	1,96310946	11,28199354
K1301	1,68624589	9,690858132
K1302	2,37679507	13,65944551
	17,4003774	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{1101}, K_{1102} >= 100 - \left(\frac{K1101_{percentage}}{K1102_{percentage}} * 100 \right) \quad \textbf{(4.3)}$$

The criterion which is stronger than other is written as bold in Table 4.3.

Table 4.3: Comparison between two organizational success criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
K1101	K1102	27,72832406
K1101	K1201	33,17359032
K1101	K1202	17,78777671
K1101	K1203	38,88941208
K1101	K1204	33,99691437
K1101	K1301	43,30553931
K1101	K1302	20,08809891
K1102	K1201	7,534440285
K1102	**K1202**	12,0913253
K1102	K1203	15,44323953
K1102	K1204	8,673647363
K1102	K1301	21,55369313
K1102	**K1302**	9,560810151
K1201	**K1202**	18,7147519
K1201	K1203	8,55323784
K1201	K1204	1,232033939
K1201	K1301	15,1615941
K1201	**K1302**	16,3748969
K1202	K1203	25,6672725
K1202	K1204	19,71621374
K1202	K1301	31,03889128
K1202	K1302	2,798029425

K1203	**K1204**	7,412528771
K1203	K1301	7,226451875
K1203	**K1302**	23,52755087
K1204	K1301	14,10331782
K1204	**K1302**	17,40518656
K1301	**K1302**	29,0537956

While this matrix is being filled, it was accepted that assumption which is shown in Table 4.4.

Table 4.4: Organizational criterions classification on Saaty Teorem

%0 - %9	1
%9 - %30	3
%30 - %50	5
%50 - %75	7
%75 - %100	9

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{8*(8-1)}{2} = 28 \quad \textbf{(4.4)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Organizational. Pairwise comparison matrix is shown in Table 4.5.

Table 4.5: Pairwise comparision matrix for organizational success factors

	K1101	K1102	K1201	K1202	K1203	K1204	K1301	K1302
K1101	1.00	3.00	5.00	3.00	5.00	5.00	5.00	3.00
K1102	0.33	1.00	1.00	0.33	3.00	1.00	3.00	1.00
K1201	0.20	1.00	1.00	0.33	1.00	1.00	3.00	0.33
K1202	0.33	3.00	3.00	1.00	3.00	3.00	5.00	1.00

K1203	0.20	0.33	1.00	0.33	1.00	1.00	1.00	0.33
K1204	0.20	1.00	1.00	0.33	1.00	1.00	3.00	0.33
K1301	0.20	0.33	0.33	0.20	1.00	0.33	1.00	0.33
K1302	0.33	1.00	3.00	1.00	3.00	3.00	3.00	1.00

Organizational consistency Ratio = % 3.6

Organizational principal Eigen Value = 8.351

These are the resulting weights for the criteria based on Organizational pairwise comparisons shown in Table 4.6.

Table 4.6: Weight of organizational success criterions

Organizational Criterion	Priority
K1101	35.5%
K1102	10.1%
K1201	7.1%
K1202	18.2%
K1203	5.3%
K1204	7.1%
K1301	3.9%
K1302	14.9%

4.1.2 Results Of Aspect Of People Success Factors

For each People detail criterions, geometric mean is calculated with 18 agile expert responder's answers which were given for people related questions.

Table 4.7: Answers of responders related to people criterions

	Eng.1	Eng.2	Eng.3	Eng.4	Eng.5	Eng.6	Eng.7	Eng.8	Eng.9	Eng.10	Eng.11	Eng.12	Eng.13	Eng.14	Eng.15	Eng.16	Eng.17	Eng.18	**Geoeann**
K2101	5	4	4	5	3	4	5	5	5	4	4	4	4	5	5	4	4	4	4,293

K2102	4	5	2	4	4	4	4	2	5	4	4	2	4	4	4	4	5	4	3,698
K2103	2	2	2	2	2	3	3	2	3	2	2	2	2	3	1	2	1	2	2,026
K2201	1	1	5	1	1	5	1	5	1	5	1	1	1	5	1	1	5	1	1,709
K2202	1	1	5	1	5	5	1	5	5	1	2	1	1	5	1	2	5	2	2,098
K2203	4	4	5	5	5	5	5	5	5	4	5	4	4	4	4	4	5	4	4,472

After calculation geometric mean, all detail criterions' percentage weight is calculated.

$$Criterion_{Percentage Value} = \frac{Total_{geometric Mean}}{Criterion_{geometric Mean}}.100 \qquad \textbf{(4.5)}$$

According to above Formula, all results are shown in Table 4.8.

Table 4.8: Geometric mean success criterions in people category

People Criterions	**Geometric Mean**	**Percentage Values**
K2101	4,2934477	23,46218637
K2102	3,6986224	20,21167456
K2103	2,026346	11,07327057
K2201	1,7099759	9,344419005
K2202	2,0989077	11,4697945
K2203	4,472136	24,43865499
	18,299436	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{2101}, K_{2102} >= 100 - \left(\frac{K2101_{percentage}}{K2102_{percentage}} * 100 \right) \qquad \textbf{(4.6)}$$

The criterion which is stronger than other is written as bold in Table 4.9.

Table 4.9: Comparison between two people succeess criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
K2101	K2102	13,854258
K2101	K2103	52,803757
K2101	K2201	60,172429
K2101	K2202	51,113701
K2101	**K2203**	3,9955907
K2102	K2103	45,213493
K2102	K2201	53,76722
K2102	K2202	43,251637
K2102	**K2203**	17,296289
K2103	K2201	15,612836
K2103	**K2202**	3,4571145
K2103	**K2203**	54,689525
K2201	**K2202**	18,530197
K2201	**K2203**	61,763775
K2202	**K2203**	53,066998

While this matrix is being filled, it was accepted that assumption which is shown in Table 4.10.

Table 4.10: People criterions classification on Saaty Teorem

%0 - %9	1
%9 - %30	3
%30 - %50	5
%50 - %75	7
%75 - %100	9

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{6*(6-1)}{2} = 15 \quad \textbf{(4.7)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to People. Pairwise comparison matrix is shown in Table 4.11.

Table 4.11: Pairwise comparision matrix for people success factors

	K2101	K2102	K2103	K2201	K2202	K2203
K2101	1.00	3.00	5.00	5.00	5.00	1.00
K2102	0.33	1.00	5.00	7.00	5.00	0.33
K2103	0.20	0.20	1.00	3.00	1.00	0.14
K2201	0.20	0.14	0.33	1.00	0.33	0.14
K2202	0.20	0.20	1.00	3.00	1.00	0.14
K2203	1.00	3.00	7.00	7.00	7.00	1.00

People Consistency Ratio = % 6

People Principal Eigen Value = 6.378

These are the resulting weights for the criteria based on People pairwise comparisons shown in Table 4.12.

Table 4.12: Weight of people success criterions

People Criterion	Priority
K2101	30.9%
K2102	19.0%
K2103	5.9%
K2201	3.3%
K2202	5.3%
K2203	35.5%

4.1.3 Results Of Aspect Of Process Success Factors

For each Process detail criterions, geometric mean is calculated with 18 agile experted responder's answers which were given for process related questions.

Table 4.13: Answers of responders related to process criterions

	Eng.1	Eng.2	Eng.3	Eng.4	Eng.5	Eng.6	Eng.7	Eng.8	Eng.9	Eng.10	Eng.11	Eng.12	Eng.13	Eng.14	Eng.15	Eng.16	Eng.17	Eng.18	**Geoeann**
K3101	3	5	5	5	1	3	1	1	1	1	5	1	3	1	3	1	1	3	1,940
K3102	5	2	3	1	2	1	5	1	1	1	1	2	1	5	3	2	1	2	1,791
K3201	4	4	5	4	5	5	4	4	4	4	4	4	3	5	5	4	4	4	4,188
K3202	1	1	3	1	3	1	5	2	1	5	1	1	1	5	3	2	5	2	1,927
K3301	3	1	5	1	1	1	1	5	1	1	1	1	1	3	3	2	1	2	1,551
K3302	4	4	5	4	2	5	3	4	4	4	5	3	4	4	5	4	3	4	3,855

After calculation geometric mean, all detail criterions' percentage weight is calculated.

$$Criterion_{PercentageValue} = \frac{Total_{geometricMean}}{Criterion_{geometricMean}}.100 \quad \textbf{(4.8)}$$

According to above Formula, all results are shown in Table 4.14.

Table 4.14: Geometric mean success criterions in process category

Process Criterions	**Geometric Mean**	**Percentage Values**
K3101	1,94026187	12,72003215
K3102	1,79113334	11,74237042
K3201	4,18830595	27,45783292
K3202	1,92760721	12,63707032
K3301	1,55106972	10,16855354
K3302	3,85521443	25,27414064
	15,2535925	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{3101}, K_{3102} >= 100 - \left(\frac{K3101_{percentage}}{K3102_{percentage}} * 100 \right) \quad \textbf{(4.9)}$$

The criterion which is stronger than other is written as bold in Table 4.15.

Table 4.15: Comparison between two process success criterions

First Criterion	**Second Criterion**	**Weight of First Criterion over Second Criterion**
K3101	K3102	7,68600049
K3101	**K3201**	53,6743042
K3101	K3202	0,65221399
K3101	K3301	20,0587434
K3101	**K3302**	49,6717521
K3102	**K3201**	57,2348974
K3102	**K3202**	7,07996301
K3102	K3301	13,402889
K3102	**K3302**	53,5399815
K3201	K3202	53,9764469
K3201	K3301	62,9666566
K3201	K3302	7,95289374
K3202	K3301	19,5339324
K3202	**K3302**	50
K3301	**K3302**	59,7669662

While this matrix is being filled, it was accepted that assumption which is shown in Table 4.16.

Table 4.16: Process criterions classification on Saaty Teorem

%0 - %9	1
%9 - %30	3
%30 - %50	5
%50 - %75	7
%75 - %100	9

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{6*(6-1)}{2} = 15 \quad \textbf{(4.10)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Process. Pairwise comparison matrix is shown in Table 4.17.

Table 4.17: Pairwise comparision matrix for process success factors

	K3101	K3102	K3201	K3202	K3301	K3302
K3101	1.00	1.00	0.14	1.00	3.00	0.20
K3102	1.00	1.00	0.14	1.00	3.00	0.14
K3201	7.00	7.00	1.00	7.00	7.00	1.00
K3202	1.00	1.00	0.14	1.00	3.00	0.20
K3301	0.33	0.33	0.14	0.33	1.00	0.14
K3302	5.00	7.00	1.00	5.00	7.00	1.00

Process Consistency Ratio = % 2.9

Process Principal Eigen Value = 6.183

These are the resulting weights for the criteria based on Process pairwise comparisons shown in Table 4.18.

Table 4.18: Weight of process success criterions

Process Criterion	Priority
K3101	7.6%
K3102	6.8%
K3201	40.0%
K3202	7.2%
K3301	3.4%
K3302	35.4%

4.1.4 Results Of Aspect Of Technical Success Factors

For each Technical detail criterions, geometric mean is calculated with 18 agile expert responder's answers which were given for technical related questions.

Table 4.19: Answers of responders related to technical criterions

	Eng.1	Eng.2	Eng.3	Eng.4	Eng.5	Eng.6	Eng.7	Eng.8	Eng.9	Eng.10	Eng.11	Eng.12	Eng.13	Eng.14	Eng.15	Eng.16	Eng.17	Eng.18	**Geoeann**
K4101	5	5	5	1	2	3	1	5	1	1	1	1	1	5	3	1	1	1	1,836
K4102	5	4	5	4	5	5	5	5	4	4	4	4	4	4	5	5	5	5	4,527
K4103	3	4	5	4	4	3	3	2	4	3	4	2	2	5	4	4	2	4	3,297
K4104	1	1	5	1	3	5	3	1	1	1	1	5	1	1	1	1	1	1	1,477
K4105	1	1	5	1	1	1	1	5	1	5	1	2	1	2	1	1	1	1	1,412
K4106	1	1	1	2	3	1	3	1	1	1	3	1	2	5	1	1	1	1	1,418
K4107	5	5	5	4	5	4	5	5	5	4	3	4	4	5	4	4	5	4	4,401
K4108	4	4	5	4	3	5	4	4	4	4	4	4	4	5	3	4	5	4	4,071
K4109	1	5	1	5	5	4	4	4	4	4	5	4	4	4	4	4	5	4	3,648

After calculation geometric mean, all detail criterion's percentage weight is calculated.

$$Criterion_{Percentage Value} = \frac{Total_{geometric Mean}}{Criterion_{geometric Mean}}.100 \quad \textbf{(4.11)}$$

According to above Formula, all results are shown in Table 4.20.

Table 4.20: Geometric mean of success criterions in technical category

Technical Criterions	Geometric Mean	Percentage Values
K4101	1,83609732	7,037506066
K4102	4,52792148	17,35489433
K4103	3,29737281	12,63837212
K4104	1,47743531	5,662804386
K4105	1,41235144	5,413346971
K4106	1,41840304	5,436541901
K4107	4,40122891	16,86929928
K4108	4,07111591	15,60402201
K4109	3,64824407	13,98321293
	26,0901703	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{4101}, K_{4102} >= 100 - \left(\frac{K4101_{percentage}}{K4102_{percentage}} * 100 \right) \quad \textbf{(4.12)}$$

The criterion which is stronger than other is written as bold in Table 4.21.

Table 4.21: Comparison between two technical success criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
K4101	**K4102**	59,44944445
K4101	**K4103**	44,31635659
K4101	K4104	19,53393244
K4101	K4105	23,07861734
K4101	K4106	22,74902714

K4101	**K4107**	58,28216721
K4101	**K4108**	54,89940951
K4101	**K4109**	49,67175213
K4102	K4103	27,1768996
K4102	K4104	67,37056258
K4102	K4105	68,80795199
K4102	K4106	68,67430134
K4102	K4107	2,798029425
K4102	K4108	10,08863718
K4102	K4109	19,42784169
K4103	K4104	55,19356187
K4103	K4105	57,16737157
K4103	K4106	56,98384374
K4103	**K4107**	25,08063368
K4103	**K4108**	19,00567613
K4103	**K4109**	9,617537953
K4104	K4105	4,405192158
K4104	K4106	3,995590692
K4104	**K4107**	66,43130049
K4104	**K4108**	63,70932839
K4104	**K4109**	59,50283806
K4105	**K4106**	0,426648597
K4105	**K4107**	67,9100662
K4105	**K4108**	65,30800221
K4105	**K4109**	61,28681587
K4106	**K4107**	67,77256832
K4106	**K4108**	65,15935508
K4106	**K4109**	61,1209389
K4107	K4108	7,500473201
K4107	K4109	17,10851351
K4108	K4109	10,38712374

While this matrix is being filled, it was accepted that assumption which is shown in Table 4.22.

Table 4.22: Technical criterions classification on Saaty Teorem

%0 - %9	1
%9 - %30	3
%30 - %50	5
%50 - %75	7
%75 - %100	9

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{9*(9-1)}{2} = 36 \quad \textbf{(4.13)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Technical. Pairwise comparison matrix is shown in Table 4.23.

Table 4.23: Pairwise comparision matrix for technical success factors

	K4101	K4102	K4103	K4104	K4105	K4106	K4107	K4108	K4109
K4101	1.00	0.14	0.20	3.00	3.00	3.00	0.14	0.14	0.20
K4102	7.00	1.00	3.00	7.00	7.00	7.00	1.00	3.00	3.00
K4103	5.00	0.33	1.00	7.00	7.00	7.00	0.33	0.33	1.00
K4104	0.33	0.14	0.14	1.00	1.00	1.00	0.14	0.14	0.14
K4105	0.33	0.14	0.14	1.00	1.00	1.00	0.14	0.14	0.14
K4106	0.33	0.14	0.14	1.00	1.00	1.00	0.14	0.14	0.14
K41	7.00	1.00	3.00	7.00	7.00	7.00	1.00	1.00	3.00

07									
K4108	7.00	0.33	3.00	7.00	7.00	7.00	1.00	1.00	3.00
K4109	5.00	0.33	1.00	7.00	7.00	7.00	0.33	0.33	1.00

Technical Consistency Ratio = % 5.3

Technical Principal Eigen Value = 9.610

These are the resulting weights for the criteria based on Technical pairwise comparisons shown in Table 4.24.

Table 4.24: Weight of technical success criterions

Technical Criterion	Priority
K4101	3.9%
K4102	25.7%
K4103	11.4%
K4104	2.13%
K4105	2.16%
K4106	2.19%
K4107	21.6%
K4108	19.8%
K4109	11.8%

4.1.5 Results Of Aspect Of Project Success Factors

For each Project detail criterions, geometric mean is calculated with 18 agile experted responder's answers which were given for project related questions.

Table 4.25: Answers of responders related to project criterions

	Eng.1	Eng.2	Eng.3	Eng.4	Eng.5	Eng.6	Eng.7	Eng.8	Eng.9	Eng.10	Eng.11	Eng.12	Eng.13	Eng.14	Eng.15	Eng.16	Eng.17	Eng.18	Geoeann
K5101	3	4	5	4	4	3	3	2	4	3	4	2	2	5	4	4	2	4	3,297
K5102	1	1	5	2	1	2	1	1	2	3	2	2	1	1	2	3	1	3	1,654
K5103	3	1	5	1	1	2	3	3	5	3	3	1	1	5	1	1	1	1	1,843
K5104	1	1	3	1	1	1	5	3	1	5	1	1	5	5	1	2	1	2	1,744

After calculation geometric mean, all detail criterion's percentage weight is calculated.

$$Criterion_{PercentageValue} = \frac{Total_{geometricMean}}{Criterion_{geometricMean}}.100 \qquad \textbf{(4.14)}$$

According to above Formula, all results are shown in Table 4.26.

Table 4.26: Geometric mean of success criterions in project category

Project Criterions	**Geometric Mean**	**Percentage Values**
K5101	3,29737281	38,60678402
K5102	1,65460834	19,37272804
K5103	1,84396457	21,58977643
K5104	1,74496981	20,43071151
	8,54091552	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{5101}, K_{5102} >= 100 - \left(\frac{K5101_{percentage}}{K5102_{percentage}} * 100 \right) \quad \textbf{(4.15)}$$

The criterion which is stronger than other is written as bold in Table 4.27.

Table 4.27: Comparison between two Project success criterions

First Criterion	**Second Criterion**	**Weight of First Criterion over Second Criterion**
K5101	K5102	49,82040456
K5101	K5103	44,07776516
K5101	K5104	47,07999636
K5102	K5103	10,26897336
K5102	K5104	5,178397598
K5103	K5104	5,368582298

While this matrix is being filled, it was accepted that assumption which is shown in Table 4.28..

Table 4.28: Project criterions classification on Saaty Teorem

%0 - %9	1
%9 - %30	3
%30 - %50	5
%50 - %75	7
%75 - %100	9

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{4*(4-1)}{2} = 6 \quad \textbf{(4.16)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Project. Pairwise comparison matrix is shown in Table 4.29.

Table 4.29: Pairwise comparision matrix for project success factors

	K5101	K5102	K5103	K5104
K5101	1.00	5.00	5.00	5.00
K5102	0.20	1.00	0.33	1.00
K5103	0.20	3.00	1.00	1.00
K5104	0.20	1.00	1.00	1.00

These are the resulting weights for the criteria based on Project pairwise comparisons shown in Table 4.30.

Table 4.30: Weight of project success criterions

Project Criterion	Priority
K5101	61.3%
K5102	9.6%
K5103	16.9%
K5104	12.3%

Project Consistency Ratio = % 5.7
Project Principal Eigen Value = 4.155

4.2 FINDINGS FOR FAILURE CRITERIONS

In this chapter, what studies were done will be explained step by step. At the beginning of Section 3, it was mentioned that Agile Methodology was examined in four main categories for failure criterions.

a. Organizational
b. People
c. Process

d. Technical

Data set was arranged as told section 3.1. And geometric mean was calculated for detail criterions belonging to each category by using Buckley approach.

$$z_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{\frac{1}{n}} \quad \textbf{(4.17)}$$

4.2.1 Results Of Aspect Of Organizational Failure Factors

For each organizational failure detail criterions, Geometric mean is calculated with 18 agile experted responder's answers which was given for organizational related questions.

$$Criterion_{Percentage Value} = \frac{Total_{geometric Mean}}{Criterion_{geometric Mean}}.100 \quad \textbf{(4.18)}$$

According to above Formula, all results are shown in Table 4.31.

Table 4.31: Geometric mean failure criterions in organizational category

Organizational Criterions	Geometric Mean	Percentage Values
F1101	2,14955421	11,25197776
F1102	2,97426921	15,56900074
F1201	1,70341263	8,916621378
F1202	1,8175934	9,514307885
F1203	2,44521285	12,79962165
F1204	1,98759733	10,40420422
F1205	1,96310946	10,27602089
F1206	1,68624589	8,826761004
F1207	2,37679507	12,44148447

	19,1037901	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{1101}, K_{1102} >= 100 - \left(\frac{K1101_{percentage}}{K1102_{percentage}} * 100 \right) \quad \textbf{(4.19)}$$

The criterion which is stronger than other is written as bold in Table 4.32.

Table 4.32: Comparison between two organizational failure criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
F1101	**F1102**	27,728324
F1101	F1201	20,755075
F1101	F1202	15,44324
F1101	**F1203**	12,091325
F1101	F1204	7,5344403
F1101	F1205	8,6736474
F1101	F1206	21,553693
F1101	**F1207**	9,5608102
F1102	F1201	42,728364
F1102	F1202	38,889412
F1102	F1203	17,787777
F1102	F1204	33,17359
F1102	F1205	33,996914
F1102	F1206	43,305539
F1102	F1207	20,088099
F2101	**F1202**	6,2819757

F2101	**F1203**	30,336836
F2101	**F1204**	14,297901
F2101	**F1205**	13,228851
F2101	F1206	1,007785
F2101	**F1207**	28,331532
F2102	**F1203**	25,667272
F2102	**F1204**	8,5532378
F2102	**F1205**	7,4125288
F2102	F1206	7,2264519
F2102	**F1207**	23,527551
F2103	F1204	18,714752
F2103	F1205	19,716214
F2103	F1206	31,038891
F2103	F1207	2,7980294
F2104	F1205	1,2320339
F2104	F1206	15,161594
F2104	**F1207**	16,374897
F2105	F1206	14,103318
F2105	**F1207**	17,405187
F2106	**F1207**	29,053796

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{9*(9-1)}{2} = 36 \quad \textbf{(4.20)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Organizational. Pairwise comparison matrix is shown in Table 4.33.

Table 4.33: Pairwise comparision matrix for organizational failure factor

	F1101	F1102	F1201	F1202	F1203	F1204	F1205	F1206	F1207
F1101	1.00	0.33	0.20	0.14	1.00	0.33	0.14	1.00	0.14
F1102	3.00	1.00	0.20	0.14	3.00	1.00	0.14	3.00	0.14
F1201	5.00	5.00	1.00	0.20	5.00	5.00	0.20	5.00	0.20
F1202	7.00	7.00	5.00	1.00	7.00	7.00	1.00	7.00	3.00
F1203	1.00	0.33	0.20	0.14	1.00	0.33	0.14	1.00	0.14
F1204	3.00	1.00	0.20	0.14	3.00	1.00	0.14	3.00	0.14
F1205	7.00	7.00	5.00	1.00	7.00	7.00	1.00	7.00	1.00
F1206	1.00	0.33	0.20	0.14	1.00	0.33	0.14	1.00	0.14
F1207	7.00	7.00	5.00	0.33	7.00	7.00	1.00	7.00	1.00

Organizational consistency Ratio = % 6.9

Organizational principal Eigen Value = 9.798

These are the resulting weights for the criteria based on Organizational pairwise comparisons shown in Table 4.34.

Table 4.34: Weight of organizational failure criterions

Organizational Criterion	Priority
F1101	%2.3
F1102	%4.35
F1201	%10.4
F1202	%28.4
F1203	%2.3
F1204	%4.30
F1205	%23.9
F1206	%2.3
F1207	%22.0

4.2.2 Results Of Aspect Of People Failure Factors

For each People detail criterions, geometric mean is calculated with 18 agile expert responder's answers which were given for people related questions.

After calculation geometric mean, all detail criterions' percentage weight is calculated.

$$Criterion_{PercentageValue} = \frac{Total_{geometricMean}}{Criterion_{geometricMean}}.100 \quad \textbf{(4.21)}$$

According to above Formula, all results are shown in Table 4.35.

Table 4.35: Geometric mean failure criterions in people category

People Criterions	Geometric Mean	Percentage Values
F2101	4,2934477	22,63902846
F2102	1,6320712	8,605789248
F2103	3,6986224	19,50255907
F2201	2,0989077	11,06738306
F2202	3,6853848	19,43275837
F2203	1,8463957	9,735906596
F2204	1,7099759	9,0165752
	18,964805	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{2101}, K_{2102} >= 100 - \left(\frac{K2101_{percentage}}{K2102_{percentage}} * 100 \right) \quad \textbf{(4.22)}$$

The criterion which is stronger than other is written as bold in Table 4.36.

Table 4.36: Comparison between two people failure criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
F2101	F2102	61,9869322
F2101	F2103	13,8542579
F2101	F2201	51,1137013
F2101	F2202	14,1625781
F2101	F2203	56,9950335
F2101	F2204	60,1724287
F2102	**F2103**	55,8735383
F2102	**F2201**	22,2418778
F2102	**F2202**	55,7150401
F2102	**F2203**	11,6077259
F2102	**F2204**	4,55589781
F2103	F2201	43,2516367
F2103	F2202	0,35790533
F2103	F2203	50,0788252
F2103	F2204	53,7672201
F2104	**F2202**	43,0478018
F2204	F2203	12,0306351
F2204	F2204	18,5301968
F2203	F2203	49,8995129
F2203	F2204	53,6011562
F2202	F2204	7,38843773

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{7*(7-1)}{2} = 21 \quad \textbf{(4.23)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to People. Pairwise comparison matrix is shown in Table 4.37.

Table 4.37: Pairwise comparision matrix for people failure factors

	F2101	F2102	F2103	F2201	F2202	F2203	F2204
F2101	1.00	7.00	3.00	7.00	3.00	7.00	7.00
F2102	0.14	1.00	0.14	0.33	0.14	0.33	1.00
F2103	0.33	7.00	1.00	5.00	1.00	7.00	7.00
F2201	0.14	3.00	0.20	1.00	0.20	3.00	3.00
F2202	0.33	7.00	1.00	5.00	1.00	5.00	7.00
F2203	0.14	3.00	0.14	0.33	0.20	1.00	1.00
F2204	0.14	1.00	0.14	0.33	0.14	1.00	1.00

People Consistency Ratio = % 5.5

People Principal Eigen Value = 7.446

These are the resulting weights for the criteria based on People pairwise comparisons shown in Table 4.38.

Table 4.38: Weight of people failure criterions

People Criterion	Priority
F2101	%39.2
F2102	%2.9
F2103	%22.2
F2201	%7.1
F2202	%21.0
F2203	%4.3
F2204	%3.3

4.2.3 Results Of Aspect Of Process Failure Factors

For each Process detail criterions, geometric mean is calculated with 18 agile expert responder's answers which were given for process related questions.

After calculation geometric mean, all detail criterions' percentage weight is calculated.

$$Criterion_{Percentage\,Value} = \frac{Total_{geometric\,Mean}}{Criterion_{geometric\,Mean}}.100 \qquad \textbf{(4.24)}$$

According to above Formula, all results are shown in Table 4.39.

Table 4.39: Geometric mean failure criterions in process category

Process Criterions	Geometric Mean	Percentage Values
F3101	1,94026187	17,02226279
F3102	1,79113334	15,71393159
F3201	4,18830595	36,74475363
F3202	1,92760721	16,91124121
F3301	1,55106972	13,60781078
	11,3983781	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{3101}, K_{3102} >= 100 - \left(\frac{K3101_{\,percentage}}{K3102_{\,percentage}} * 100 \right) \qquad \textbf{(4.25)}$$

The criterion which is stronger than other is written as bold in Table 4.40.

Table 4.40: Comparison between two process failure criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
K3101	F3102	7,6860005
K3101	**F3201**	53,674304
K3101	F3202	0,652214
K3101	F3301	20,058743
K3102	**F3201**	57,234897
K3102	**F3202**	7,079963

K3102	F3301	13,402889
K3201	F3202	53,976447
K3201	F3301	62,966657
K3202	F3301	19,533932

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{5*(5-1)}{2} = 10 \quad \textbf{(4.26)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Process. Pairwise comparison matrix is shown in Table 4.41.

Table 4.41: Pairwise comparision matrix for process failure factors

	K3101	K3102	K3201	K3202	K3301
K3101	1.00	1.00	0.20	1.00	3.00
K3102	1.00	1.00	0.20	1.00	3.00
K3201	5.00	5.00	1.00	5.00	5.00
K3202	1.00	1.00	0.20	1.00	3.00
K3301	0.33	0.33	0.20	0.33	1.00

Process Consistency Ratio = % 3.4

Process Principal Eigen Value = 5.151

These are the resulting weights for the criteria based on Process pairwise comparisons shown in Table 4.42.

Table 4.42: Weight of process failure criterions

Process Criterion	Priority
K3101	13.2%
K3102	13.2%
K3201	54.6%

K3202	13.9%
K3301	5.8%

4.2.4 Results Of Aspect Of Technical Failure Factors

For each Technical detail criterions, geometric mean is calculated with 18 agile expert responder's answers which was given for technical related questions.

After calculation geometric mean, all detail criterions' percentage weight is calculated.

$$Criterion_{Percentage Value} = \frac{Total_{geometric Mean}}{Criterion_{geometric Mean}}.100 \quad \textbf{(4.27)}$$

According to above Formula, all results are shown in Table 4.43.

Table 4.43: Geometric mean of failure criterions in technical category

Technical Criterions	Geometric Mean	Percentage Values
F4101	1.42996915	6.292432638
F4102	1.8175934	7.998133433
F4103	2.61712653	11.516397
F4104	4.40122891	19.3671566
F4105	1.47743531	6.501302605
F4106	1.65460834	7.280934352
F4107	4.07111591	17.91452821
F4108	1.40092783	6.164639307
F4109	3.85521443	16.96447585
	22.7252198	**100**

Now, percentage values are ready, there is no obstacle to determine weight vector for pairwise comparison.

While preparing weight vector, this Formula was used.

$$comparison< K_{4101}, K_{4102} >= 100 - \left(\frac{K4101_{percentage}}{K4102_{percentage}} * 100 \right) \quad \textbf{(4.28)}$$

The criterion which is stronger than other is written as bold in Table 4.44.

Table 4.44: Comparison between two technical failure criterions

First Criterion	Second Criterion	Weight of First Criterion over Second Criterion
F4101	**F4102**	21.326236
F4101	**F4103**	45.3611
F4101	**F4104**	67.509776
F4101	**F4105**	3.2127403
F4101	**F4106**	13.576578
F4101	**F4107**	64.875253
F4101	F4108	2.030905
F4101	**F4109**	62.908181
F4102	**F4103**	30.550037
F4102	**F4104**	58.702593
F4102	F4105	18.714752
F4102	F4106	8.9670807
F4102	**F4107**	55.353927
F4102	F4108	22.924025
F4102	**F4109**	52.853637
F4103	**F4104**	40.53646
F4103	F4105	43.547425
F4103	F4106	36.777671
F4103	**F4107**	35.714763
F4103	F4108	46.470764
F4103	**F4109**	32.114631
F4104	F4105	66.4313
F4104	F4106	62.405765
F4104	F4107	7.5004732

F4104	F4108	68.169621
F4104	F4109	12.405955
F4105	**F4106**	10.707853
F4105	**F4107**	63.709328
F4105	F4108	5.1783976
F4105	**F4109**	61.676962
F4106	**F4107**	59.357376
F4106	F4108	15.331755
F4106	**F4109**	57.081289
F4107	F4108	65.588604
F4107	**F4109**	5.3032508
F4108	**F4109**	63.661481

At this time, everything is ready to create pairwise comparison matrix.

$$Comparison\ Count = \frac{9*(9-1)}{2} = 36 \quad \textbf{(4.29)}$$

These resulting weights are based on the principal eigenvector of the decision matrix of detailed criterions related to Technical. Pairwise comparison matrix is shown in Table 4.45.

Table 4.45: Pairwise comparision matrix for technical failure factor

	F4101	F4102	F4103	F4104	F4105	F4106	F4107	F4108	F4109
F4101	1.00	0.33	0.20	0.14	1.00	0.33	0.14	1.00	0.14
F4102	3.00	1.00	0.20	0.14	3.00	1.00	0.14	3.00	0.14
F4103	5.00	5.00	1.00	0.20	5.00	5.00	0.20	5.00	0.20
F4104	7.00	7.00	5.00	1.00	7.00	7.00	1.00	7.00	3.00
F4105	1.00	0.33	0.20	0.14	1.00	0.33	0.14	1.00	0.14
F4106	3.00	1.00	0.20	0.14	3.00	1.00	0.14	3.00	0.14
F4107	7.00	7.00	5.00	1.00	7.00	7.00	1.00	7.00	1.00
F4108	1.00	0.33	0.20	0.14	1.00	0.33	0.14	1.00	0.14

F4109	7.00	7.00	5.00	0.33	7.00	7.00	1.00	7.00	1.00

Technical Consistency Ratio = % 6.9

Technical Principal Eigen Value = 9.798

These are the resulting weights for the criteria based on Technical pairwise comparisons shown in Table 4.46.

Table 4.46: Weight of technical failure criterions

Technical Criterion	Priority
F4101	2.3%
F4102	4.3%
F4103	10.4%
F4104	28.4%
F4105	2.3%
F4106	4.3%
F4107	23.9%
F4108	2.3%
F4109	22.0%

5. DISCUSSION

In these studies, opinions taken from expert engineers have been classified by splitting into five categories as mentioned before. In this section, findings that are obtained as a result of these studies, is going to be interpreted by agile manifesto is taken as basis.

Especially, according to criteria that are examined under organizational category, it is concluded that number of employees does not have an effect on success. In same manner, despite the expected, it is concluded that sitting together of project team, do not have any effect on success. Despite it is defended in agile manifesto that face to face conversation is an effective and fast method, as a result of this study and by contrast with agile manifesto, to have conversation permanently, its better to have conversation written. As a result of studies, participants have stated that organizing their own team is increasing the efficiency and motivation. But in organizational criteria, it can be obviously observed that a strong administrator support is very important.

Later on, "people" factor of the results was examined. Participants mainly focused on that people who are in charge of management should have knowledge and be in accord with the team. Besides they specified being in accord with the team is more important than the level of knowledge. While In Agile manifest, it is emphasized that working with customer, if needed, being a partner with customer, most of the participants stated they applied that but they complained how it is difficult to work with customers.

In the analysis studies about technical factors, according to the most of the participants, it is concluded that code implementation should be simple, understandable and designed in a way that satisfies the needs in the quickest way, which is supporting agile manifesto. Other results are, code should be refactored time to time, it is important that code should be controlled(inspection) by a second person periodically and even taking advantage of some necessary tools is essential. It is emphasized that it is necessary to share (delivery) work which is done with customer frequently. These studies show that, it is also important in practice and companies that uses agile, are doing deliveries with

minimum 4 week periods. Finally, it is concluded that testing process should be carried out properly and in there should be at least one tester in every scrum. According to the studies, it has been revealed that preparing documents it one of the greatest favors which is done to the customers. But studies also shows that properly running code should be more preferred to intensive documentation. Lastly, another result is when the team that will do the work, determines the performing time of a project, it increases the moral and the motivation.

The importance of the well-defined requirements, understandability by everyone for the process factors faced out by this study. However, in the process factors; the most important thing considered by participants was customer affect during the project period. It is shown that the opinion; a better product will be produced, when the feedback from the customers are taken into account during the product development.
This is a principle which is also indicated by agile manifesto. Probability of a better result is shown up when Agile is applied during the project management.

As a result; under the project factor criteria; the scalability of the project, and if required having the whole project in multiple phases results are gained. Furthermore, importance of the making priorities by team by making the customer convinced is also a gained result of that study.

6. CONCLUSION

As mentioned beginning of this study, usage of agile software development process is measured thanks to the survey. Then, 18 agile expert engineers were selected and their answers were used in this study. Fuzzy AHP was applied to data set as mentioned previous section. As a result it is clearly seen that a criterion, which belongs to one of five categories, have a priority degree over other criterions at the same category.

For the organizational success category, “Strong executive support” is much more important than the other criterions. This criterion is 34 percent of sum of all organizational factors. The second important criterion is the “Organizations where agile methodology is universally accepted”. This criterion is 18 percent of total organizational factors. The third important criterion is “team size being too large”. This criterion is also 15 percent of sum of all organizational criterions. Other criterions are very closely to each other. The forth is “Committed sponsor or manager” with 10 percent, the fifth is “Cooperative organizational culture instead of hierarchal” with 7 percent and the sixth is “Facility with proper agile-style work environment” with the same percentage of the fifth. The before last criterion is “Oral culture placing high value on face-to-face communication” with 5 percent. The lowest priority belongs to “Collocation of the whole team” with 2 percent.

For the organizational failure category, “Organizational principles excessively political” is much more important than the other criterions. This criterion is 29 percent of sum of all organizational factors. The second important criterion is the “Unsuitable facility/working environment”. This criterion is 23 percent of total technical factors. The third important criterion is “Team sizes are too large”. This criterion is also 22 percent of sum of all organizational criterions. The forth important criterion is “Organization is multi-regional and too large” which is 10.5 percent. Other criterions are very closely to each other. The fifth is “Absence of management support” with 5 percent, and the same percentage is “External pressure to follow traditional waterfall process”. The other criterions are “Organizational culture traditional or outdated” and

“Locally distributed teams instead of co-location” They are 3 percentages of total organizational factors.

For the people success category, “Managers who have light-touch or adaptive management style” is much more important than the other criterions. This criterion is 36 percent of sum of all people factors. The second important criterion is the “Team members with high competence and expertise”. This criterion is 31 percent of total people factors. The third important criterion is “Managers knowledgeable in agile process Good customer relationship”. This criterion is also 19 percent of sum of all people criterions. Other criterions are very closely to each other. The forth and the fifth have same percentage, these are “Good customer relationship” and “Coherent, self-organizing teamwork” with 5.7 percent. The lowest priority belongs to “Team members with great motivation” with 3.3 percent.

For the people failure category, “Insufficient experience” is much more important than the other criterions. This criterion is 40 percent of sum of all people factors. The second important criterion is the “Insufficient project management proficiency”. This criterion is 22 percent of total people factors. The third important criterion is “Resistance from teams or individuals”. This criterion is also 21 percent of sum of all people criterions. The forth criterion which is “Absence of team work” has 7 percent. Other criterions are very closely to each other. The fifth and the sixth have almost same percentage; these are “Weak customer relationship” and “Demotivation of team members/team” with 4 percent. The lowest priority belongs to “Lack of the required skill set” with 2.9 percent.

For the technical success category, “Pursuing simple design” is much more important than the other criterions. This criterion is 25.7 percent of sum of all technical factors. The second important criterion is the “Correct integration testing”. This criterion is 21.6 percent of total technical factors. The third important criterion is “Appropriate technical training to team”. This criterion is also 20 percent of sum of all technical criterions. The forth is “Accurate sizing/design estimate” with 11.4 percent, and the same percentage with the fifth is “Rigorous refactoring activities” with 11.4 percent. “Right amount of documentation”, “Regular delivery of software” and “Delivering most important

features first” criterions have same percentage with 2 percent of sum of all technical criterions.

For the technical failure category, “Lack of tester in the team” is much more important than the other criterions. This criterion is 29 percent of sum of all technical factors. The second important criterion is the “Insufficient training”. This criterion is 23 percent of total technical factors. The third important criterion is “Absence of risk analysis, lessons-learned”. This criterion is also 22 percent of sum of all technical criterions. The forth important criterion is “Insufficient test cases” which is 10.5 percent. Other criterions are very closely to each other. The fifth is “Lack of code review” with 5 percent, and the same percentage is “Unrealistic/short design estimates”. The other criterions are “Absence of developer involvement in prioritization” and “Unsuitable technology and tools” They are 3 percentages of total technical factors.

For the process success category, “Strong customer commitment and presence” is much more important than the other criterions. This criterion is 40 percent of sum of all process factors. The second important criterion is the “Following agile-oriented project management process”. This criterion is 35.4 percent of total process factors. Other criterions are very closely to each other. The third and four important criterions are “Clear and well understood project scope and requirements” and “Customer having full authority” with 7.2 percent. The fifth is “Accurate project planning” with 6.8 percent of the sum of all process criterions. The lowest priority belongs to “Following agile-oriented requirement management process” with 3.4 percent.

For the process failure category, “Vague customer role” is much more important than the other criterions. This criterion is 55 percent of sum of all process factors. The second important criterion is the “Absence of customer presence”. This criterion is 14 percent of total project factors. The other criterions have equal importance with 13 percentages. They are “Imprecise project scope and requirements” and “Inaccurate project planning”. Finally the lowest priority belongs to “Absence of agile progress tracking methods/systems” with 6 percent.

For the project success category, “Project type being of variable scope with emergent requirement” is much more important than the other criterions. This criterion is 61 percent of sum of all project factors. The second important criterion is the “Projects with no multiple independent teams”. This criterion is 17 percent of total project factors. The third important criterions is “Projects with up-front cost evaluation done” with 12.3 percent and finally the lowest priority belongs to “Project type being of variable scope with emergent requirement” with 9.6 percent.

REFERENCES

Books

Cockburn, A., Highsmith, J. 2001. *Agile software development: the people factor*, Issue No.11 - November (2001 vol.34), pp: 131-133, Published by the IEEE Computer Society.

Highsmith, J., 2010. *Agile project management: creating innovative products.* Pearson Education; ISBN-13: 03216583959

Kong, S., 2007. *Agile software development methodology: effects on perceived software*, Google eBooks

Chang, C-H, 1999, *Evaluating Weapon Systems Using Ranking Fuzzy Numbers, Fuzzy Sets And Systems***.**

Chang, C-W. 2008, *Evaluating And Controlling Silicon Wafer Slicing Quality using Fuzzy Analytic Hierarchy And Sensitivity Analysis*.

Chang, N-B. hang, Y-H.and Cheng, H-W. 2007, *Fair Fund Distrubition For A Municipal incinerator Using GIS-Based Fuzzy Analytic Hierarchy Process*

Ali Babar, M., Brown, A.W., Mistrik, I., 2013, *Agile Software Architecture: Aligning Agile Processes with Software Architecture*

7. James J. Buckley , Eslami, Esfandiar., 2002, An Introduction to Fuzzy Logic

James .J. Buckley, E. Eslami, 2003, *Uncertain Probabilities I: The Discrete Case; Soft Computing*

J.J. Buckley, E. Eslami, 2003, *Uncertain Probabilities II: The Continuous Case; Soft Computing*

J.J. Buckley, 2005, *Fuzzy Statistics: Hypothesis Testing; Soft Computing*

Ali Babar, 2013, *M., Making Software Architecture and Agile Approaches Work Together*

Periodicals

Abdulaziz I. A. and Mayhew, P., 2013. *An investigation of the critical success factors of IT projects in saudi arabian public organizations*, IBIMA Publishing.

Ambler, S., 2010. *Scaling agile: an executive guide*, IBM agility at scale.

Bullen, C.V., Rokhart, J.F.,A, 1981. *Primer on critical success factors*, working paper no.69, Massachusetts institute of technology.

Charotte, R., 2005. *Why software fails.* IEEE Spectrum.,pp. 42-49.

Chow, T., Cao, D., 1981. *A survey study on critical success factors of agile software*, Journal of Systems and Software, Volume 81, Issue 6, pp. 961–971

Doherty, M. 2012. *Examining project manager insights of agile and traditional success factors for information technology projects: a Q-Methodology study*, PhD, Marian University, Doctoral Dissertation.

Gorans, P., Kruchten, P., 2014. *A guide to critical success factors in agile delivery*, IBM center for the business of government.

Larman, C., 2004. *Agile and iterative development: a manager's guide.* Addison-Wesley. p. 25.

Lindvall M, Basili V, Boehm B. 2002. *Empirical findings in agile methods*, Volume 2418 of the series Lecture Notes in Computer Science, pp 197-207

Misra, S. C., Kumar, V., and Kumar, U., 2006. *Success factors of agile software development*, International Conference on Software Engineering Research and Practice, June, pp. 26-29

Nasir, M., Sahibuddin, S., 2011. *Critical success factors for software projects: a comparative study.* Scientific Research and Essays, pp. 2174-2186.

Nasir, M., 2011. *Addressing a critical success factor for software projects: a multi-round delphi study of TSP*, International Journal of the Physical Sciences Vol. 6(5), pp. 1213-1232.

Oferi, D., 2013. *Project management practices and critical success factors–a developing country perspective*, International Journal of Business & Management.

Peng, D.X.; Lai, F., 2012. *Using partial least squares in operations management research: a practical guideline and summary of past research*. Journal of Operations Management, pp. 467–480.

Wan, J. and Wang, R., 2010. *Empirical research on critical success factors of agile software process improvement*, Journal of Software Engineering and Applications, Vol. 3 No. 12, pp. 1131-1140.

Wan, J., Zhu, Y., Zeng, M., 2013. *Case study on critical success factors of running scrum*, Journal of Software Engineering and Applications.

Dagdeviren, M. and Eren, T., 2001, *Tedarikçi Firma Seçiminde Analitik Hiyerarsi Prosesi ve 0-1 Hedef Programlama Yöntemlerinin Kullanılması*, Gazi University Engineering Faculty Brosure

Demirtaş, N., Tuzkaya, U. R., & Şeker, Ş. 2014. *Project Management Methodology Selection Using SWOT-Fuzzy AHP*. World Congress On Engineering, 2014.

Derindere M. S., 2013, *Project and process management methods influencing agile software development,* Fatih University.

Elibol, M., 2014, *Mobile application development with agile software development methodology for clinical trials,* Istanbul University

Others

Manifesto for agile software development: [online] www.agilemanifesto.org. [accessed 02/03/2016]

Campanelli, *A. S.*, 2016. *A Tailoring criteria model for agile practices adoption* http://www.fumec.br/revistas/sigc/article/view/3219 [accessed 12/03/2016]

Full Definition of AGILE: http://www.merriam-webster.com/dictionary/agile [accessed 01/05/2016]

eWorkshop, 2002. *Summary of the First eWorkshop on Agile Methods.* [online] http://fcmd.umd.edu/projects/Agile/Summary/SummaryPF.htm. [accessed 08/05/2016]

Mansor, Z., Yahya, S., Habibah, N., 2014. *Success determinants in agile software methodology,* [online] https://www.academia.edu/662661/Success_Determinants_in_Agile_Software_Development_Methodology. [accessed 12/04/2016]

Senapathi, M. and Srinivassan A. , 2014. *An empirical investigation of the factors affecting agile usage* [online] https://www.researchgate.net/publication/266658847_An_empirical_investigation_of_the_factors_affecting_agile_usage [accessed 02/02/2016]

Mougouei, D., Shen, H., Ali Babar, M.,2015, *Partial Selection of Agile Software Requirements, International Journal of Software Engineering and Its Applications*

Alpaslan G, 2015, *Model driven software development with agile proces, Yıldız Teknik University.*

APPENDICES

APPENDIX-1, SURVEY QUESTIONS

SECTION A: Company Data and Personal Information

A1. Personal Information:

Questions

1. First Name/Last Name (optional):

   …...

2. Age:

   …..

3. Gender (Male/Female):

   …..

4. Graduate Faculty (e.g. Computer Engineering, Electric/Electronic Engineering):

   ……..

5. Please enter number of years how long you have been involved in software/systems development:

   …..

6. Please enter number of years how long you have been using agile methods or agile practices:

   ……..

7. Please enter number of years how many projects you have used Agile methods/practices:

   …….

8. Please select which one your current position describes

   - Agile Coach

- Scrum Master
- Business Stakeholder
- Business Analyst
- Designer
- Tester
- Project Manager
- IT Delivery Manager
- Other (please specify below):

  ……

9. Please select how large project you have used an agile methodology.

   - Large (Time > 1 year / team >= 30 people)
   - Medium (6 months < Time > 1 year / 20 > team > 30 people)
   - Small (3 months > Time > 6 months / 10 > team > 20 people)
   - Very small (Time < 3 months / team < 10 people)

A2. Personal Influencers:

The following questions relates to your beliefs on the teams that you have most worked with or currently working with on agile projects.

Questions
10. My team members have a strong sense of identification and commitment to the team o Strongly Disagree(SD) o Disagree(D) o Neither Agree nor Disagree(NAorD) o Agree(A) o Strongly Agree(SA)
11. My team members have the willingness to learn and change

- SD
- D
- NAorD
- A
- SA

12. My team members doesn’t have strong interpersonal and communication skills

    - SD
    - D
    - NAorD
    - A
    - SA

13. My team members are technically competent

    - SD
    - D
    - NAorD
    - A
    - SA

14. My team members have collaborative attitude

    - SD
    - D
    - NAorD
    - A
    - SA

SECTION B:
B1. Organization Dimension:

Questions
15. Agile methodologies recognize the value of customer engagement and welcomes customer representative in agile team. o SD o D o NAorD o A o SA
16. Customer involvement in early life cycle of project development motivates customers and makes them feel responsible for the project.

- SD
- D
- NAorD
- A
- SA

17. Management commitment is not required to support the team to take self-initiatives, decisions and handle the circumstances of the results.

    - SD
    - D
    - NAorD
    - A
    - SA

18. Committed project sponsor or project manager is required for the investment decisions, project plans and empowers the successful project delivery.

    - SD
    - D
    - NAorD
    - A
    - SA

19. Corporate culture should support the introduction of agile methodologies for being more cooperative instead of hierarchical.

    - SD
    - D
    - NAorD
    - A
    - SA

20. An organization where agile methodology is followed is more dynamic and fast responsive.

    - SD
    - D
    - NAorD
    - A
    - SA

21. Organizational culture should place high value on face-to-face communication to support agile culture.

- SD
- D
- NAorD
- A
- SA

22. Facility with proper agile-style work environment will positively influence team communication and organization culture.

- SD
- D
- NAorD
- A
- SA

23. One of the factors that is likely to positively influence the success of an agile software development project is the co-location of the organization of the teams.

- SD
- D
- NAorD
- A
- SA

24. Companies involved in distributed international projects will be affected by the cultural and political situations in those regions.

- SD
- D
- NAorD
- A
- SA

25. An agile team should be no larger than 9 people.

- SD
- D
- NAorD
- A
- SA

26. Customer involvement in early life cycle of project development doesn't help to create much better business engagement and customer satisfaction.

○ SD ○ D ○ NAorD ○ A ○ SA

B2. People Dimension:

Questions
27. Daily sync meeting with the customer should be arranged. ○ SD ○ D ○ NAorD ○ A ○ SA
28. Developers don’t need to be experienced with the required skillset. ○ SD ○ D ○ NAorD ○ A ○ SA
29. The customer needs to work locally with the developers. ○ SD ○ D ○ NAorD ○ A ○ SA
30. Daily sync meetings with the customer need to be organized in terms of face-to-face meetings. ○ SD ○ D ○ NAorD ○ A ○ SA
31. The motivation of the individuals (developers) is crucial in the agile

development.

- SD
- D
- NAorD
- A
- SA

32. Project Manager is not responsible for the motivation of developers.

- SD
- D
- NAorD
- A
- SA

33. Working environment affects the motivation of the developers in the agile development.

- SD
- D
- NAorD
- A
- SA

34. Technical challenges affects the motivation of the developers in the agile development.

- SD
- D
- NAorD
- A
- SA

35. Insufficient agile experience of a project manager doesn't affect agile development.

- SD
- D
- NAorD
- A
- SA

36. Developers' resistance to agile methodology doesn't cause any failures of

agile projects. ○ SD ○ D ○ NAorD ○ A ○ SA
37. Lack of teamwork results in failures of agile projects. ○ SD ○ D ○ NAorD ○ A ○ SA

B3. Process Dimension:

Questions
38. Requirements should be determined by the customer. ○ SD ○ D ○ NAorD ○ A ○ SA
39. The priorization should be made by the customer. ○ SD ○ D ○ NAorD ○ A ○ SA
40. Clarification of requirements does not have an impact on agile projects. ○ SD ○ D ○ NAorD ○ A ○ SA
41. Progress of the scrum team should be tracked daily using required tools.

○ SD ○ D ○ NAorD ○ A ○ SA

B4. Technical Dimension:

Questions
42. Before starting to implementation process, coding standards should be pre-defined. ○ SD ○ D ○ NAorD ○ A ○ SA
43. A second engineer should review an engineer's code in terms of code standards. ○ SD ○ D ○ NAorD ○ A ○ SA
44. An engineer should design and implement the code without considering customer's future requirements/enhancements. ○ SD ○ D ○ NAorD ○ A ○ SA
45. As part of scrum meetings, each engineer should tell what and how he/she did in current work-period to others. ○ SD ○ D ○ NAorD ○ A ○ SA

46. Technical document should be updated clearly during each work-period.

    - SD
    - D
    - NAorD
    - A
    - SA

47. Technical document should include information only the customer needs to know.

    - SD
    - D
    - NAorD
    - A
    - SA

48. Code delivery to the customer should be done frequently (along with each/every sprint).

    - SD
    - D
    - NAorD
    - A
    - SA

49. Most important features of the project should be delivered firstly.

    - SD
    - D
    - NAorD
    - A
    - SA

50. The person who implemented the code and the person who will test the code should be the same person.

    - SD
    - D
    - NAorD
    - A
    - SA

51. Test scenarios should be completed before code implementation.

- SD
- D
- NAorD
- A
- SA

52. Minimum %40 of the project team should consist of expert engineers.

- SD
- D
- NAorD
- A
- SA

53. Training period is not required to consider and plan in project plans.

- SD
- D
- NAorD
- A
- SA

54. Integration tests should be run automatically with each delivery.

- SD
- D
- NAorD
- A
- SA

55. Agile development doesn’t increase the level of software quality.

- SD
- D
- NAorD
- A
- SA

B5. Project Dimension:

Questions
56. A requirement cannot be changed by customer in any phase of the project. ○ SD ○ D ○ NAorD ○ A ○ SA
57. Design estimates should be given to the agile team that will work for the project. ○ SD ○ D ○ NAorD ○ A ○ SA
58. A project which is comprehensive and difficult to control should consist of small teams. ○ SD ○ D ○ NAorD ○ A ○ SA
59. If there are multiple teams, each team should be aware of their responsibilities and dependencies. ○ SD ○ D ○ NAorD ○ A ○ SA
60. Design estimates should be given after a requirement is clear and well understood. ○ SD ○ D ○ NAorD ○ A ○ SA

61. Customer should define the priority of requirements.

    - SD
    - D
    - NAorD
    - A
    - SA

62. Retrospective meetings that are arranged to evaluate the project don't help to increase quality.

    - SD
    - D
    - NAorD
    - A
    - SA

63. Suitable tools should be selected for each project phase and these tools should be used effectively by the team members.

    - SD
    - D
    - NAorD
    - A
    - SA

64. Design estimates should be given by the agile team that will work for the project.

    - SD
    - D
    - NAorD
    - A
    - SA

CIRRICULUM VITAE

Name Surname : Seydi MİHMANLI

Address : Yenişehir Mahallesi, Millet Caddesi, Akkaya Sokak, Bankacılar Sitesi A Blok Daire:13 Kurtköy Pendik/İstanbul

Place and Year of Birth : Gaziantep, 1985

Foreign Language : English

Primary Education : (Gazi Orta Okulu, 1999)

Secondary Education : (Ayten-Kemal Akınal Anadolu Lisesi, 2003)

Undergraduate : (Sakarya University, 2009)

Working Life : CTECH (R&D software Engineer, 2011-2013)
SIEMENS (R&D Software Developer Engineer, 2013-2014)
NETAS (Senior Software Developer Engineer, 2014 -)